

Institution: Loughborough University		
Unit of Assessment: B12: Engineering		
Title of case study: Worldwide elimination of facial injuries in cricket through research informed helmet standards		
Period when the underpinning research was undertaken: 2001 – 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:
Andy Harland	Professor of Sports Technology	2001 to present
Sean Mitchell	Senior Lecturer	2000 to present
Ben Halkon	Senior Lecturer in Sports Technology	2009 to 2016
Steve Rothberg	Professor of Vibration Engineering	1995 to present
Paul Sherratt	Senior Lecturer in Sports Technology	2013 to present
Period when the claimed impact occurred: 2014 – present		
Is this case study continued from a case study submitted in 2014? No		
1. Summary of the impact (indicative maximum 100 words)		
<p>Research at Loughborough University has played a critical role in the elimination of serious and life-threatening facial and neck injuries among batters in cricket globally. By understanding the collision dynamics during short duration impacts, two original tests were included in revisions to the British Standard (BS7928) which were then adopted by the International Cricket Council and applied across 104 cricket playing nations. Prior to the research, more than one serious facial injury occurred in professional cricket every 5000 balls bowled. By eliminating this injury, up to 40 career-ending and potential life-threatening injuries have been prevented to date. In addition, the research led to economic benefits for helmet manufacturers and test houses and to culture change in the approach to head injury taken by cricket and other sports.</p>		
2. Underpinning research (indicative maximum 500 words)		
<p>The Sports Technology Research Group at Loughborough University has established an international reputation in research applied to products used in sporting applications, developing specific expertise in collisions between rigid and deformable bodies. Recognising their successes, EPSRC awarded funding to equip a bespoke laboratory in 1999 (GR/M54407/01, £512k). In 2008 a further £15M investment by East Midlands Development Agency and Loughborough University [EMX04083/CRN147] expanded the group's capabilities to establish the Sports Technology Institute.</p> <p>Since 2001 Prof. Harland and Dr Mitchell have led empirical and computational research that has been published internationally in the field of ball/equipment/player impacts and the design and analysis of personal protective equipment (PPE).</p> <p>Our research into injury mitigation has followed a 3-phase strategy: understand and quantify the human injury scenario [R1, R2]; simulate and explore the mechanisms of injury using appropriate human surrogates, projectiles and impact-inducing devices [R2, R3, R4]; and support progress towards injury-reduction strategies or improved PPE products. Research has been supported by the Innovative Manufacturing Research Centre (EP/E002323/1, £17.8M, 2006) in partnership with leading brands (Nike, adidas, Dunlop-Slazenger) and National and International Sporting Federations (International Cricket Council (ICC), International Hockey Federation (FIH) and England and Wales Cricket Board (ECB)).</p>		

Impact case study (REF3)

Research published in 2013 [R2] demonstrated that typical energy-equivalent test methods used to assess PPE misrepresent short duration impacts (<50 ms) and so risk being ineffective when determining the protective performance of products.

By devising an experimental method and apparatus capable of replicating the cricket ball mass and impact velocity during collision, a more effective testing regime was proven. Practical investigation considered the influence of the headform mounting method [R3] which justified the use of a constrained headform in a standard test, offering a more rapid, straightforward and cost-effective solution than the freely suspended alternative.

Since their introduction in the 1970s, cricket helmets have proven effective in reducing instances of skull fracture and have evolved to include grilles intended to prevent facial injury. Despite this, epidemiological research (Ranson *et al.*, BJSM 2013) revealed an increasing problem of career-, and potentially life-threatening facial injuries in high-profile cricket. The ECB programme recorded 46 facial injuries in the UK leading to 492 days of rehabilitation and 1 enforced retirement between 2009-2014. Based on their expertise, Loughborough received funding from the ICC to investigate the mechanics of cricket ball collisions to the head and face and efficacy of helmets.

Research into existing helmet performance identified two major failures: deformation of the grille causing facial contact or penetration of the ball between the helmet peak and grille. Helmet samples from leading manufacturers were analysed and deficiencies identified, generally concerned with the displacement and flexion of key features during the initial few milliseconds of collision. These results were found to be consistent with reported outcomes of on-field failings.

Once Harland demonstrated, for the first time, the advanced testing regime was capable of reliably evidencing helmet effectiveness when protecting the wearer's facial region, refinements resulting in a simplified version were shown to be effective, reliable and sufficiently cost effective to administer. This was published in BS7928:2013 [R5] following consensual adoption by the relevant panel.

Following the tragic death of Australian Test cricketer Philip Hughes who was struck on the neck by a ball, several manufacturers began selling, and many players began wearing, neck protectors. Since these products were not subject to any standard, the ICC again provided funds to develop new tests based on his research informed understanding. In 2015 Harland and Mitchell established a robust and viable method of certifying neck protector efficacy. In contrast to the faceguard specification, a falling hemispherical striker drop test was shown to be effective and economical and was subsequently published as an amendment to BS7928:2013+A1:2019.

3. References to the research (indicative maximum of six references)

- R1** Walker, P.J.; Rothberg, Steve; Holmes, Chris E.; Harland, Andy R. (2010). Design of a force acquisition system for high-energy short-duration impacts. *Proceedings of the Institution of Mechanical Engineers, Part P: Journal of Sports Engineering and Technology*, 224 (2), pp. 129-39. DOI: <https://doi.org/10.1243/17543371JSET65>
- R2** Velani, Nikunj; Harland, Andy R., Halkon, Ben J. (2013). The development of a test methodology for the determination of cricket batting helmet performance when subjected to ballistic impacts. *IRCOBI Conference Proceedings: International Research Council on the Biomechanics of Injury*, IRC-13-47, pp. 424-30. Available: http://www.ircobi.org/wordpress/downloads/irc13/pdf_files/47.pdf
- R3** Stone, Ben W.; Harland, Andy R.; Jones, James P.; Mitchell, Sean R.; Sherratt, Paul J.; Ranson, Craig A.; Halkon, Ben J. (2017). On the dynamic response of an instrumented headform for alternative mounting stiffnesses when subjected to ballistic impacts. *Proceedings of the Institution of Mechanical Engineers, Part P: Journal of Sports*

Engineering and Technology, 231 (4), pp. 324-35. DOI:

<https://doi.org/10.1177/1754337117703574>

R4 Payne, Thomas; Mitchell, Sean R.; Halkon, Ben J.; Bibb, Richard J.; Waters, Mark (2015). Development of a synthetic human thigh impact surrogate for sports personal protective equipment testing. *Proceedings of the Institution of Mechanical Engineers, Part P: Journal of Sports Engineering and Technology*, 230 (1), pp. 5-16. DOI: <https://doi.org/10.1177/1754337115582294>.

R5 BS 7928:2013+A1:2019 Specification for head protectors for cricketers. Published by BSI Standards Limited 2019. ISBN 978 0 539 02175 2; ICS 13.340.20; 97.220.40

The journal papers referenced were all published in internationally leading peer-reviewed journals in the field of sports engineering. R3 resulted from research funded by and co-authored by the International Cricket Council medical committee.

4. Details of the impact (indicative maximum 750 words)

Loughborough research and expertise in short duration impacts in cricket has been, according to the English Cricket Board's Chief Medical Officer, central to replicating, understanding and identifying "essential changes that were necessary to safeguard the health and wellbeing of players" [S1] and has "played a pivotal role in the progress in safety standards" [S3].

Improving the safety of cricketers has always provided the primary motivation for the work carried out at Loughborough and in addition to the research the need to engage with a wider network of stakeholders was recognised at an early stage. Prof. Harland "was an important member" [S2] of the British Standard BS7929 committee where he developed strong relationships with equipment manufacturers, governing bodies, standards agencies and test houses. Each of the leading manufacturers were invited into the Loughborough laboratories for individual product assessments. They also "hosted international forums for 'helmet development' [...] to provide leadership in potential innovation and improvements in helmet design" [S1], and, by sharing latest research findings, were able to establish a position of trust and confidence within the stakeholder community.

The research has led to the following evidenced impacts:

1. Established and adopted new standards for helmet and neck protection in cricket internationally

The research methodologies and findings described in Section 2 were refined and distilled into a series of tests that were included in the 2013 revision of *BS7928 Specification for Head Protectors for Cricketers*. This created a pathway to the current impact that all helmets sold in the UK since 2014 must satisfy performance standards "based exclusively on Loughborough University research" [S2].

Satisfied by the "rigour of the Loughborough University research that underpinned the new standard" [S1], Prof. Nick Peirce, Chief Medical Officer, ECB, was

"able to recommend that helmets conforming to BS7928 be mandated in all professional matches played in the UK. This requirement was included in playing regulations by ECB ahead of the 2016 season" [S1].

In June 2016, Dr Craig Ranson, a member of the International Cricket Council (ICC) Medical Committee,

"presented to the ICC Cricket Committee who recommended that the revised British Standard BS7928:2013 be adopted across all cricket playing nations. Loughborough

University research was central to this presentation and all of the laboratory-based evidence and findings were based on work carried out at Loughborough” [S2].

The next President of the MCC, Clare Connor CBE, who was one of the members of the ICC Cricket Committee, confirmed that

“the scientific basis on which the standard had been based [...] presented the evidence to support a compelling case for the committee to recommend that all cricket helmets should be certified to this standard” [S3].

On 1 January 2017 [S4] BS7928:2013 was duly mandated across all 104 full and associate member nations spread across 5 continents, covering “300 million players” [S1].

In 2019, a second revision to BS7928 (amendment +A1:2019), was also underpinned by Loughborough research and was “*vital in establishing the methodology and assessment criteria by which neck protectors could be certified*” [S1].

2. Elimination of serious and life-threatening facial injuries

Prior to 2014, significant facial injuries were “*occurring with a frequency of more than 1 significant injury per 5,000 deliveries bowled*” [S1]. The implementation of the revised British Standard BS7928:2013 has, according to the ECB’s CMO

“brought about a step change in significant facial injuries, effectively eliminating them from the game” [S1].

Since its implementation in 2014, Prof. Peirce has confirmed, based on ECB Injury surveillance, that he “*is not aware of any reported facial injuries recorded from players wearing a helmet conforming to the revised standard in the UK or internationally*” [S1].

Throughout the world, “the effect of the standard revision and the generation of new helmet products, both of which were fundamentally influenced by Loughborough research, has been dramatic.” The ICC Medical Committee Chair further reported that

“International and ECB injury surveillance since 2016 has demonstrated that serious helmet related facial injuries [...] have been removed from the game” [S2].

Prof. Peirce estimates the number of injuries prevented internationally to be “*as many as 40 career-ending and indeed potential life-threatening injuries in the professional game*” [S1]. Moreover, since the implementation of BS7928:2013+A1:2019 “*there have been no reports of serious injuries to the base of the skull and adjacent region of the neck from players wearing a certified neck protector*” [S1].

3. Economic benefits for helmet manufacturers and test houses

We ensured that cricketers benefited from the research findings by working in partnership with manufacturers and test houses. As the ICC Medical Committee Chair testifies,

“Each of the manufacturers was supported through their product development to ensure that not only did the standard represent the state of the art in player protection, but that the market would be served by a range of competitive products” [S2].

The ICC now maintains a list of 137 approved helmet models from 18 manufacturers [S4], which has created a new and sustainable line of business for INSPEC International Ltd, Salford, UK, the laboratory accredited to certify to BS7928:2013 and BS7928:2013 +A1:2019.

In addition to the immediate and sometimes long-lasting health detriment caused by facial injuries, National and professional teams have seen an economic benefit, since

“every day a player is injured and unavailable for selection, the ECB is subject to medical costs and a loss of income” [S1].

4. Culture change in the approach to head injury taken by cricket and other sports

Taken together, our research has changed attitudes to head injury across the game. The England and Wales Cricket Board’s Chief Medical Officer reported that Loughborough’s research into the prevention of head, facial and neck injuries has

“underpinned and facilitated significant changes in attitudes, standards, policy, helmet design and testing in cricket” [S1]

Across the cricket playing world, this culture change allowed the International Cricket Council to confirm that the *“critical improvements that have been made have made cricket a safer and more attractive proposition” [S2]*. Regarding the latter, the 2019 cricket world cup attracted 675 million unique viewers across 220 territories. Organisers, sponsors, and viewers were able to enjoy the spectacle of high-quality cricket without fear of witnessing dangerous facial injury.

The effect of our research [R2, R3, R5] into injury prevention in cricket has been extended into other sports. For instance, the International Hockey Federation has reported that the research *“inspired consideration of hockey’s protective equipment standards and changed our understanding of the risks and urgency in addressing these” [S5]*.

5. Sources to corroborate the impact (indicative maximum of 10 references)

S1 Letter from ECB Chief Medical Officer, Prof Nick Peirce, BS7928:2019 Committee Chair

S2 Letter from Dr Craig Ranson, ICC Medical Committee 2008-2017, BS7928:2013 Committee Chair

S3 Letter from Clare Connor CBE, Chair of ICC Women’s Committee; former Member of the International Council Cricket Committee for six years; England & Wales Cricket Board’s Managing Director of Women’s Cricket; Chair of International Cricket Council Women’s Committee; the next President of the MCC (from 1 October 2021)

S4 International Cricket Council List of Conforming Helmets (accessed January 2021)

S5 Letter from A Cox, Facilities & Equipment Manager, International Hockey Federation (FIH)