Analysis of Head Impact Kinematics in Collegiate and Elite Women's Rugby Union

Freja Petrie, Dr Desney Greybe, Victoria Hayden, Georgia Weall, Dr Elisabeth Williams

Swansea University
Prifysgol Abertawe
School of Sport and Exercise Sciences
Ysgol Chwaraeon a Gwyddorau Ymarfer Corff

Background

Female participation in rugby has seen fantastic growth following the recent professionalisation of the women's sport in 2018 [1]. Involvement in the sport greatly improves resilience [2], quality of life and ability to cope with stress [3]. The physicality of the game empowers women and encourages focus on performance rather than social ideals of appearance [4]. Involvement within the sport should therefore be considered of great benefit to the mental, physical and social health of women.

However, the benefits of rugby participation are tarnished by the unacceptable concussion incidence within the sport. At the community level, 75% of male players have suffered at least one concussion [5]. These figures have sparked research effort in males, yet the female demographic is consistently absent from these studies [6]. Non-scalable anatomical differences within female brains increase the vulnerability to injury [7], with women being 2.6 times as likely to suffer a concussion [8] and suffer greater symptom burden than men following equal impact magnitudes [9].

Current recommendations of tackle technique are developed from sample populations that lack female representation. These results have limited generalisability to women on account of biological and social differences, namely differing axonal structure [7], cervical anatomy [10], exposure to contact sports and physical literacy [11]. As women suffer repeated head impacts, the accumulation of damage can initiate a cascade of irreversible neurodegeneration [12]. To prevent a future epidemic of dementia-related diseases, as has been seen in American football and in men's rugby, exposure to concussive and subconcussive events must be minimised.

Methods

The aim of this study was to analyse head impact kinematics observed within collegiate and elite women's rugby union matches. In the collegiate demographic, six matches were video analysed to identify the kinematic variables associated with head acceleration events (HAEs). These players were also fitted with bespoke instrumented mouthguards (iMGs), with tight sensor-skull coupling to minimise soft tissue artefact.

The iMG system recorded linear and rotational acceleration for any HAE that exceeded a 10g threshold. iMG data was transmitted in real time to a pitch side edge device, where linear and rotational acceleration time curves (Figure 1) were displayed. These data were later verified using video footage and post processing included filtering and waveform characterisation.

Each verified HAE was coded for variables including tackle height, head/arm positioning, falling technique and speed into contact. All other tackles were then coded using the same criteria to understand the kinematic differences related to HAEs. In the elite demographic, video footage from two matches between four world top-ten national teams were analysed, where impact kinematics were classified consistent with the coding of collegiate players.

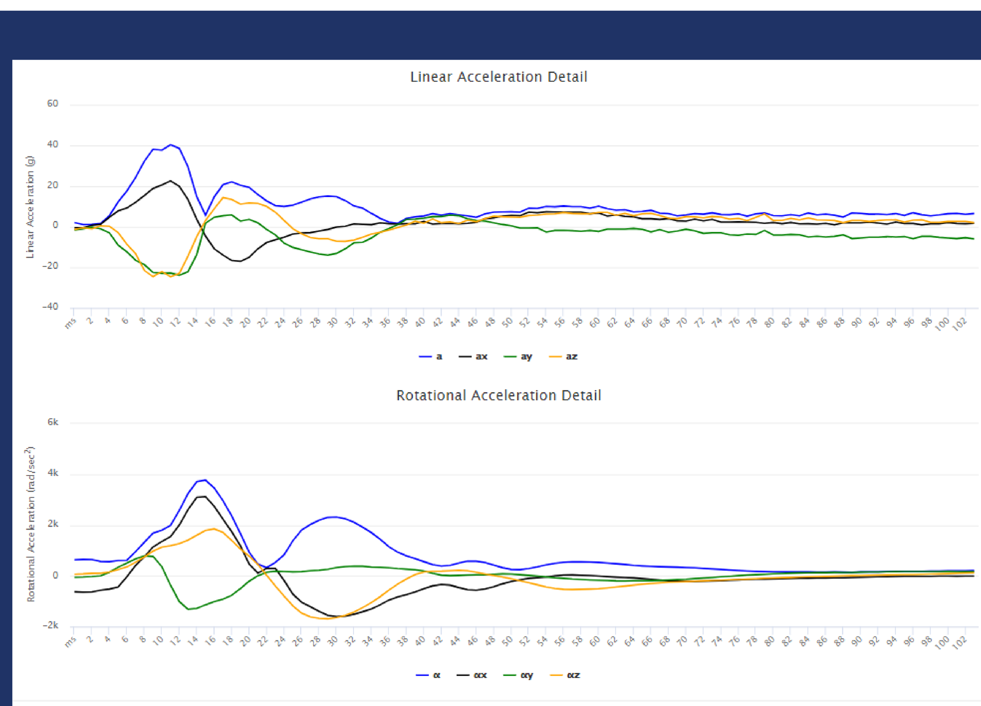


Figure 1: A representative iMG acceleration-time curve


Figure 3: A still image of a HTG impact seen in a collegiate player

Results

Of the six collegiate matches the most common cause of HAE was player to player contact (54%) (Figure 2), followed by head to ground impacts (HTG) 27% (Figure 3). This differed to the predominantly male-derived existing literature. For all collegiate video-verified HAEs, the iMG data (Figure 4) showed the average PLA (peak linear acceleration) and PRA (peak rotational acceleration) as 14.6 g (±7.4) and 1033 rads/s^2 (±717) respectively. These HTG impacts appeared consistent with a whiplash action as the head impacted the ground, often with a magnitude ~30 g (max PLA 36.6 g, PRA 3304 rads/s^2). HTG impacts were more commonly seen in the ball carrier than in the tackler. The average PLA and PRA of the tackler during HTG impacts were 17 g (± 6.1) and 1118 rads/s^2 (± 764) respectively. The average PLA and PRA of the ball carrier during HTG were 17 g (± 7.8) and 1197 rads/s^2 (± 470) respectively.

Video analysis of the elite players, in comparison, saw very few HTG impacts (Figures 5 and 6). In the collegiate game 17.4% of all tackles resulted in a whiplash action of the head, however, in the elite teams this percentage was much lower: only 2.6% of all tackles resulted in this style of whiplash in the world number one team, with 3.7%, 4.3% and 6.3% for the world ranked 2nd, 4th and 9th teams respectively.

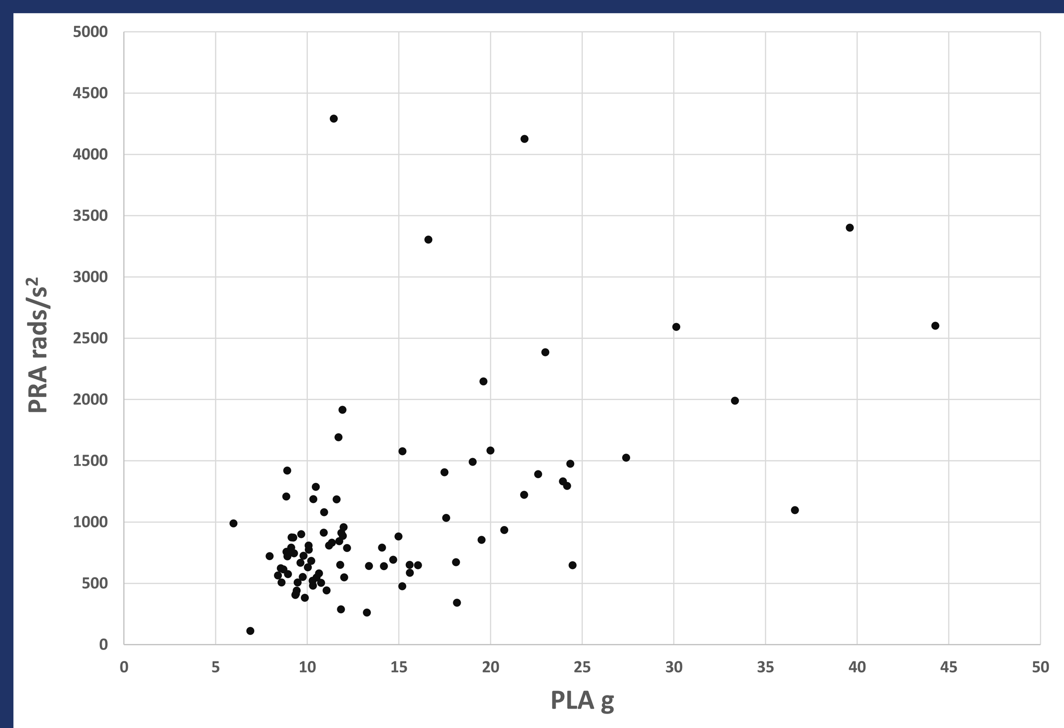
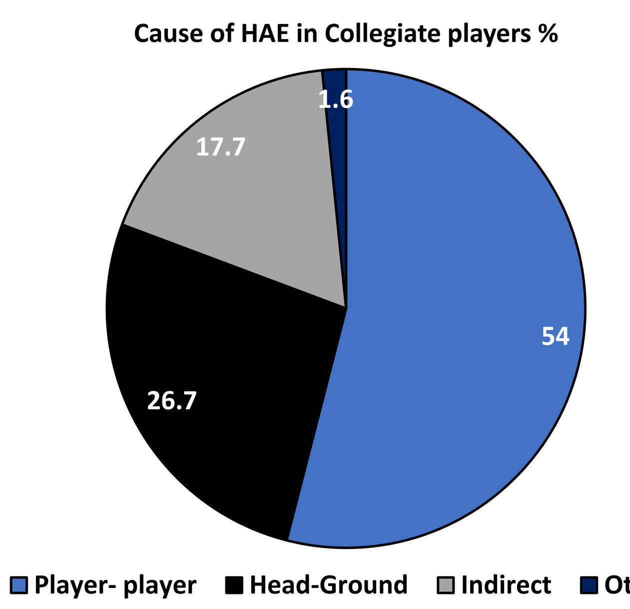


Figure 4: Scatter plot to show PLA and PRA of verified impacts for the collegiate cohort

Conclusion

The results of this study highlight a need for the collection of female derived data to develop an evidence base relating to causes of HAEs.

The kinematic breakdown of HAEs both in elite and lower level female players differ from male derived published data on which injury prevention strategies are based. Unique female physiology, neck strength, playing experience and physical literacy need to be carefully considered to develop targeted female injury prevention strategies.



Figures 2: Cause of HAE in collegiate players (%)

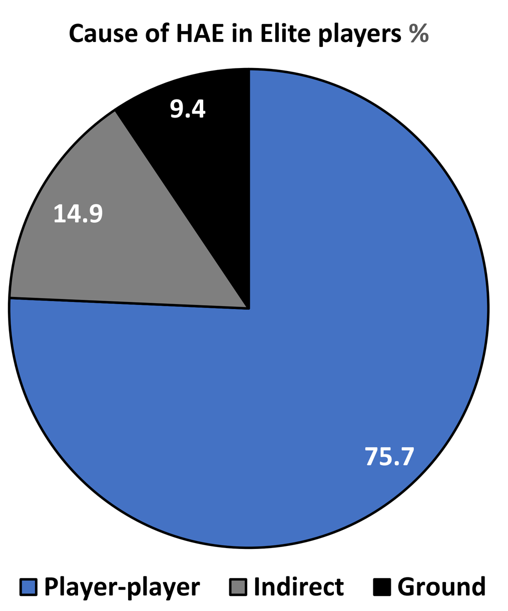


Figure 6: Cause of HAE in elite players (%)


Figure 5: A still image of an elite player where a HTG impact has been avoided

kess 2
Ysgoloriaethau Sgiliau Economi Gwybodaeth
Knowledge Economy Skills Scholarships

Knowledge Economy Skills Scholarships (KESS 2) is a pan-Wales higher level skills initiative led by Bangor University on behalf of the HE sector in Wales. It is part funded by the Welsh Government's European Social Fund (ESF) convergence programme for West Wales and the Valleys.

keytree
Keytree Ltd industrial partner

References

[1] World Rugby (2018) http://publications.worldrugby.org/yearinreview2018/en/1-1
[2] Ho, et al., *BMC Pediatr.*, vol. 15, no. 1, p. 48, Dec. 2015.
[3] Eime, et al., *Int. J. Behav. Nutr. Phys. Act.*, vol. 10, no. 1, pp. 1–14, Dec. 2013.
[4] Fields & Comstock, *Women Sport Phys. Act.* ., vol. 17, no. 2, pp. 8–18, Aug. 2016.
[5] Hume *et al.*, *Sport. Med*, vol. 47, pp. 1209–1220, 2017.
[6] Costello *et al.*, *Eur. J. Sport Sci.*, vol. 14, no. 8, pp. 847–851, Nov. 2014.
[7] Dollé *et al.*, *Exp. Neurol.*, vol. 300, pp. 121–134, Feb. 2018.
[8] Antona-Makoshi, *et al.*, *Accid. Anal. Prev.*, vol. 117, pp. 98–105, Aug. 2018.
[9] Henry *et al.*, *Neurosurgery*, vol. 78, no. 2, pp. 232–241, Feb. 2016.
[10] Stemper *et al.*, *Spine (Phila. Pa. 1976).*, vol. 33, no. 2, pp. E44–E49, Jan. 2008.
[11] Tyler *et al.*, *J. Phys. Act. Heal.*, vol. 13, no. 11, pp. S330–S336, Nov. 2016.
[12] Fann *et al.*, *The Lancet Psychiatry*, vol. 5, no. 5, pp. 424–431, May 2018.

Contact: Freja Petrie , School of Sport and Exercise Science, Swansea University
853877@Swansea.ac.uk.