The Kinematics of Football (Soccer) Heading Inside and Outside the Penalty Area

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Oscar W. Stelzer-Hiller, Graham Askew, James Tooby, Darek Sokol-Randell, Gregory J. Tierney,

I. INTRODUCTION

Unlike many other contact sports, in Football (Soccer) head acceleration events (HAE) occur primarily from players deliberately contacting the ball using their unprotected head to manipulate its movement [1-3]. Recent investigations have linked participation in professional football with a significantly higher risk of both neurodegenerative disease development and related mortality [4]. It is unclear whether observed chronic neurological impairments can be directly attributed to repetitive heading exposure during an athlete's playing career [5], however evidence is mounting for the association between repetitive HAE exposure, heading frequency and acute neurological effects [6-7]. There is a current gap in research for the independent, simultaneous assessment of the frequency and biomechanical characteristics of heading to progress the understanding of whether short-term cognitive function is affected by heading exposure and not participation [11]. Ball velocity exhibits a significant positive effect on head kinematics during heading, with different skills producing varying ball velocities [12-13]. As such, the potential contribution of heading at different pitch locations on brain injury cannot be disregarded and a recent heading mitigation strategy proposed banning heading outside of the penalty area [14]. In this study, custom-fit instrumented mouthguards (iMG) and video footage were used to measure head kinematics during in-game football heading, drawing comparison between the magnitudes endured both inside and outside of the penalty areas. By understanding the pitch locations in which the magnitude of heading kinematics are highest, it is hoped this study will inform the development of risk-reduction strategies for heading.

II. METHODS

Male recreational University football players (*n = 15, age = 20 ± 1 years)* were recruited via a convenience sample. Participants wore Prevent Biometrics' custom-fit iMG [15] during 11-a-side matches in a weekly intra-university league, observing 15 matches. The iMG incorporated a tri-axial linear accelerometer and a tri-axial gyroscope, recording linear and angular head kinematics during HAEs at a sampling rate of 3.2 kHz and over a range of ±200 g and ±35 rad/s, respectively, and has been previously validated for direct head impacts using dummy headforms but has not been specifically validated for use in football heading [16]. Data recording was triggered by a minimum HAE single-axis trigger value of 5 g and measured 10 ms of pre-trigger data and 40 ms of post-trigger data. Peak linear acceleration (PLA), peak angular acceleration (PAA), and peak change in angular velocity (ΔPAV) were recorded. HAE verification was conducted initially using an impact detection algorithm [15] then using video footage recorded at either 720p (*n = 2*) or 1080p (*n = 9*) quality with cameras directed toward the pitch from the corners and on each end of the halfway line. Only HAE obviously associated with a deliberate head-to-ball contact after video verification were included in the analysis. Video analysis of verified HAE was conducted to assess whether headers occurred inside or outside the penalty areas.

III. INITIAL FINDINGS

The frequency distribution and median and interquartile ranges of header induced HAE are presented in Fig. 1 and Fig. 2. 23.0% of all HAE from headers were below PLA of 10 g, 56.4% below 15 g, 84.8% below 20 g, and 97.6% below 30 g. Headers outside the box (n = 133, 81.6%) occurred more often than headers inside the box (n = 30, 18.4%).

Oscar W. Stelzer-Hiller is a MSc student in Sport and Exercise Science (sp17os@leeds.ac.uk) and Graham Askew is an Associate Professor in Biomechanics at the University of Leeds (g.n.Askew@leeds.ac.uk), James Tooby is a PhD student in Sport and Exercise Science at Leeds Beckett University (j.tooby@leedsbeckett.ac.uk), Darek Sokol-Randell is a PhD Candidate (dsokolrandell@gmail.com) and Gregory J. Tierney (g.tierney@Ulster.ac.uk) is an Assistant Professor in Biomechanics at Ulster University.

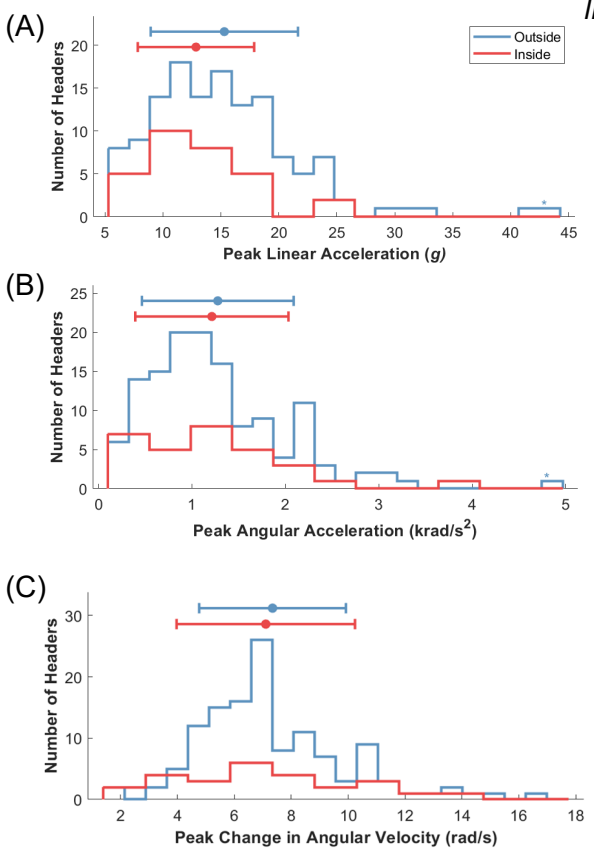

Fig. 1. Frequency distributions of headers inside and outside of the penalty area, with plots showing the median and interquartile ranges (**A**) PLA, (**B**) PAA, and (**C**) ΔPAV. Asterisks indicate HAE above 40 *g* (*n = 1)*.

IV. DISCUSSION

No effect of pitch location was observed between heading kinematics inside and outside of the box, however a large percentage of headers occurred outside of the box (Figure 1), with preliminary analysis indicating all headers produced similar magnitudes for PLA, PAA and ΔPAV, regardless of pitch location (Figure 2). Accordingly, the proposed heading mitigation strategy may reduce the number of headers in a match but have minimal effect on the kinematic magnitudes sustained during a header event. Due to minimal studies reporting actual kinematics of heading exposure, drawing comparisons between resultant PLA, PAA and ΔPAV and clinical outcomes is difficult. Future research may seek to use this methodology to assess the effect of the match event preceding the header, e.g., throw-in, goal kick, corner, and header type, e.g., clearance, interception, shot, on head kinematics. The introduction of policy alterations that target identifiable instances of high-magnitude headers may reduce the potential risk of football participation on both long- and short-term brain health. However, study designs incorporating sufficient clinical assessment is needed to assess this.

V. REFERENCES

[1] Meaney, D. F., Smith, D. H., Clin Sports Med, 2011.
[2] Abrahams, S. et al, BMJ Open Sport Exerc., 2014.
[3] McCunn, Heading in Football 2021.
[4] Mackay, D. F. et al, N Engl J Med, 2019.
[5] Mainwaring, L. et al, Int J Psychophysiol, 2018.
[6] Bunc, G et al, Med Arch, 2017.
[7] Di Virgilio, T. G. et al, EBioMedicine, 2016.
[8] Levitch, C. F. et al, J Int Neuropsychol Soc, 2018.
[9] Caramelli, P. et al, Alzheimers. Dement., 2020.
[10] Stewart, W. F. et al, Front Neurol., 2018.
[11] McCunn, R. et al, Int. J. Sports Med, 2021.
[12] Harriss, A. et al, Musculoskelet Sci Pract, 2019.
[13] Tierney, G. J. et al, Scand J Med Sci Sports, 2020.
[14] Stewarts Law LLP, [Online], 2022. Available from: https://www.stewartslaw.com/news/football-and-dementia-are-players-getting-enough-protection-against-the-risks-of-brain-injury/ . [Accessed 24th October 2021].
[15] Prevent Biometrics. Edina, Minnesota, United States
[16] Kieffer, E. E. et al, Ann Biomed Eng, 2020.