Measurement of head forces magnitude and location during live scrummaging

Pavlos Silvestros[1], Eoin Cremen[2], Ezio Preatoni[1], Elena Seminati[1] and Dario Cazzola[1]
[1]Department for Health, University of Bath, Bath, UK
[2]Bath Rugby, Bath, UK
Email: p.silvestros@bath.ac.uk

Summary

Understanding the magnitude and location of the head forces experienced by front row players during scrummaging is key to study cervical spine injury mechanisms. A novel experimental protocol was devised to measure head forces and estimate the location of the point of application of the force across different engagement conditions.

Introduction

External loads applied to the head of rugby players during scrummaging plays an important role in acute and chronic cervical spine injury. Previous studies have highlighted the high impact loads experienced by rugby players at shoulder level during both machine [1] and live scrummaging [2]. However, loads applied directly to the head have never been measured due to the experimental challenges. Importance must be placed on load management by coaches to optimise performance during competition by maximising training adaptations whilst minimising negative effects of training (e.g. fatigue repetitive strain). The aim of this study was to devise a new experimental protocol to measure the load applied onto the head of front row players, and estimate the point of application of the force across different live-scrummaging conditions.

Methods

Sixteen academy-level players participated in the study, and three front-row players were asked to wear scrum caps instrumented with two pressure sensors (3005E VersaTek-XL, Tekscan) stuck to their interior surface. The experimental protocol included two sessions. An initial session consisted of the registration of sensor placement with respect to rugby players' head, and sensor calibration. Sensor registration was completed via 3D scanning and palpation of nine anatomical markers on players' heads while they wore an instrumented scrum cap. Sensors were calibrated against an instrumented scrum machine whilst players leant against a scrum machine pad with their head. Centre of pressure (CoP) was spatially transformed from the sensors' planar surface onto a sphere fitted to the marker positions on the players' head via stereographic projection. This was then visualised on the skull of a musculoskeletal (MSK) model after the position of the scanned markers were registered to it. In the second 'on-field' session the players performed a series of different scrum setups under the supervision of experienced coaches: 1vs1, 3vs3, HS (variation of 3v3), 6vs6, 8vs8. Peak and average loads during the engagement and sustained push phases were calculated as well as the CoP trajectory (Figure 1).

Results and Discussion

Overall, there was no significant effect of scrum engagements on force magnitude across the three front-row players. The *1vs1* condition produced forces that were comparable or even higher than the other conditions for the tight-head and loose-head during both the engagement and sustained push phases (Table 1). The CoP of the head force originated at the vertex of the head and remain near the crown region throughout the trials.

Table 1: Mean force (N) magnitude acting on the head of the hooker (HK), loose-head (LH), and tight-head (TH) in the different scrum conditions. ENG= engagement , SUS= sustained-push phase.

ENG	**1v1**	**HS**	**3v3**	**6v6**	**8v8**
HK	N/A	247 ± 185	230 ± 171	163 ± 122	229 ± 141
LH	596 ± 124	442 ± 75	357 ± 112	367 ± 165	368 ± 158
TH	278 ± 38	126 ± 21	251 ± 164	273 ± 140	460 ± 299
SUS	**1v1**	**HS**	**3v3**	**6v6**	**8v8**
HK	N/A	344 ± 179	291± 159	114 ± 38	461 ± 230
LH	260 ± 62	304 ± 95	240 ± 113	161 ± 55	172 ± 83
TH	456 ± 211	317 ± 141	317 ± 100	426 ± 170	455 ± 246

Although no previous data related to head force magnitude during scrummaging is available, results from our work seem coherent with maximal neck forces recorded in rugby players [3]. Correct identification of the CoP location on the head is valuable for future MSK modelling investigations as it will inform the location of force application in inverse and forward analyses. However the validity of head force estimation via pressure sensors should be further explored.

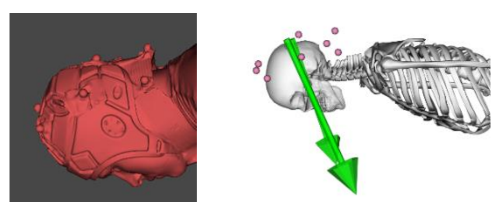

Figure 1. 3D scan of a forward player wearing instrumented scrum cap (left). Registration of CoP and force to the MSK model (right).

Conclusions

A novel experimental protocol demonstrated to be applicable to live sporting scenarios and allowed estimating the forces experienced by front-row players during different scrum setups. Initial results showed similar loading across these scrums setups in spite of the added player number.

Acknowledgments

This study was funded by the RFU Injured Player Foundation.

References

[1] Cazzola et al. (2017). *PloS one*, **12(1)**: e0169329.
[2] Preatoni et al. (2015). *Scan J Med Sci Sports,* **26(12)**: 1398-1407.
[3] Du Toit DE et al. (2004). *SA.J.Res.S.PE.Rec.*, **26(2)**: 33-50.