

An Assessment of a Novel Approach for Determining the Player Kinematics in Elite Rugby Union Players.

Gregory Tierney, Tron Krosshaug, Fiona Wilson, Karl Denvir, Tobias Wahl, Mohammad HaBayyari, Mark Carroll, Ciaran Simms

I. INTRODUCTION

Rugby is intrinsically an impact sport which results in concussions being a frequent injury within the game with repeated concussion being linked to early-onset dementia and depression. Therefore a greater understanding of the dynamics of head impacts in rugby and the mechanism of concussion is required. Little detailed analysis of real head impact cases has been performed.

II. METHODS

Model-Based Image-Matching (MBIM) can be used to measure three-dimensional temporal joint angle histories, velocities and accelerations using video sequences from un-calibrated cameras. The video resolution was 1080p with one camera view recorded at 25 fps and another at 125 fps. The reconstruction is to a sample case of a head impact to a rugby player tackling an opposing player. The matching was performed using 3-D animation software Poser 4 and Poser Pro Pack (Curious Labs Inc, Santa Cruz, California) developed by Krosshaug and Bahr [1]. The virtual surroundings are based on the dimensions of the sport field. A skeleton model from Zygote Media Group Inc (Provo, Utah) is then used to fit the player's anthropometry (Figure 1) for each video frame. Once the matching is done, the kinematics can be extracted from the animation program.



Figure 1: The skeleton model matched to the tackling player's anthropometry for a given video frame

Initial MADYMO multibody simulations (Figure 2) were ran using the tackling player's MBIM head inputs upon impact to see how the outputs compare. The tackled player's inputs were gained through video inspection.

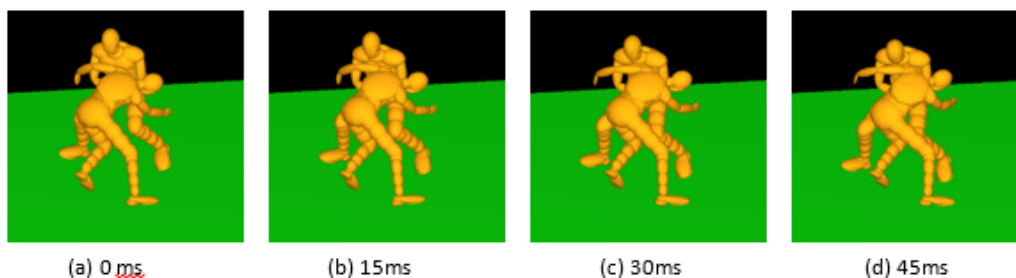


Figure 2: MADYMO simulation at given time frames.

III. INITIAL FINDINGS

Table 1 shows a summary of the main kinematic features of the sample case.

Change in velocity (m/s)	Peak acceleration (m/s ²)	Average acceleration (m/s ²)	Duration of Impact (ms)	Change in angular velocity (rad/s)	Average acceleration (rad/s ²)
6.6	138	82.5	80	33	950

Table 1: The linear and rotational kinematic data extracted from sample head impact case

Figure 3 shows the time history of the head velocity components whereas Figure 4 shows the corresponding head angular velocity components about the 3 axes of the head. Figure 5 shows a comparison of the MBIM and MADYMO data for the local head linear velocity components.

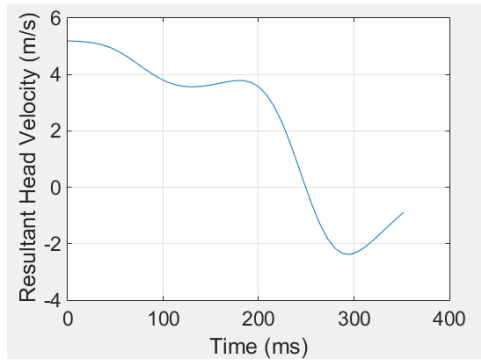


Figure 3: The resultant head velocity.

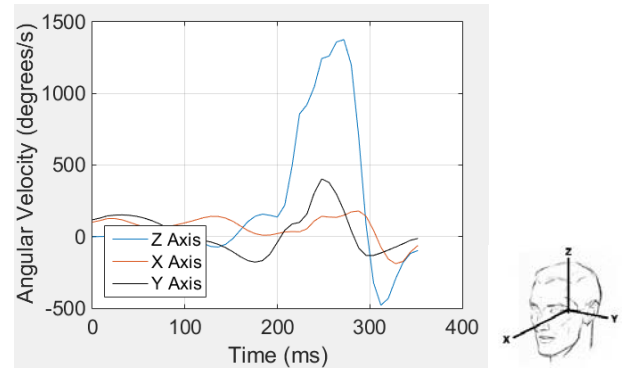


Figure 4: The head angular velocity.

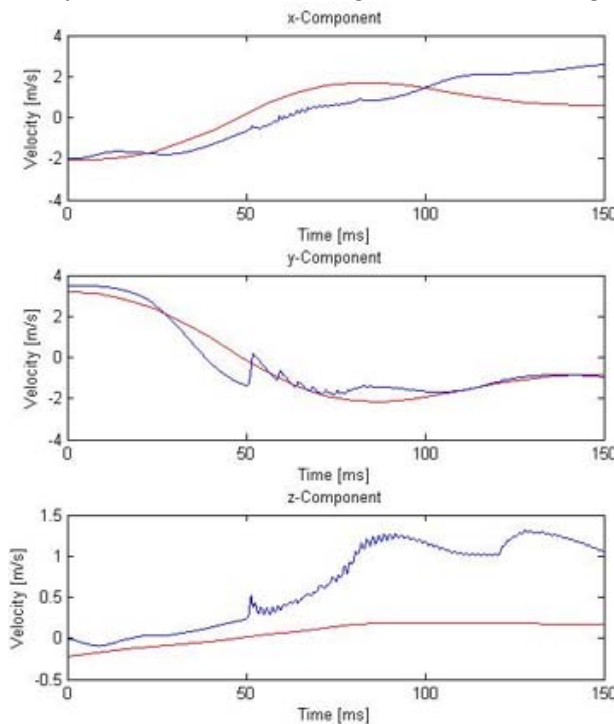


Figure 5: Comparison of the head velocity components between the MADYMO (blue) and MBIM data (red).

DISCUSSION

The peak linear and rotational accelerations from this case were significantly less than reported for head impact cases in American Football (81-106g and 5022-7951 rad/s² respectively) [2]. This may be due to the absence of helmets in rugby resulting in a more damped impact. Instrumented helmets record at a higher frequency than 125 Hz which allows higher accelerations to be detected. The change in linear and rotational velocity values (6.6m/s and 33 rad/s) are in the same range as previous rugby head impact studies [3–4]. The MADYMO simulation agrees relatively well with the MBIM data except for velocity in the z-direction. The method can be improved by inputting the MBIM kinematic data of more body parts as well as inputting the tackled players MBIM kinematic data also. This initial study shows the MBIM approach can work for rugby head impacts and the method should be combined with head impact assessment data and applied to a number of head impact cases to establish thresholds for concussion injuries in rugby.

IV. REFERENCES

- [1] Krosshaug *et al*, J Biomech, 38: 919-929, 2005.
- [2] McIntosh *et al*, BMJ Open, 4: e005078, 2014.
- [3] McIntosh *et al*, Med Sci Sports Exerc, 32: 1980-1984, 2000.
- [4] Patton *et al*, J Sports Eng Tech, 226: 177-184, 2012.