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Risk factors of concussion in Rugby: a video analysis

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1. Introduction

Rugby is a high-impact team sport where on average, a player sustains 39 impacts per match (Lokteff *et al.* 2022). Since its professionalisation in 1995, the effective playing time and the number of tackles per game have increased dramatically. Because of this dramatic increase, the 6th International Consensus (Patricios *et al.* 2023) identified the risk factors associated with concussion. The Head Injury Assessment (HIA) protocol has been integrated into elite rugby since 2015 to help referees and medical teams identify the risk of concussion during a match. The protocol consists of 3 steps. HIA1 involves removing the player from the field (HIA1 positive). Unfortunately, the resources available to rugby professionals do not define what criteria are important to consider when analyzing the risk of a collision scenario.

To address this issue, the present study aims to characterise typical concussion scenarios through video analysis of rugby impacts that led to an HIA protocol, while attempting to identify whether cervical spine motion, impact areas and impact type could be critical criteria associated with a positive assessment.

2. Methods

2.1 Study context and cohort

The study focused on 180 professional rugby matches played during the 2022-2023 and 2023-2024 rugby seasons. Data extraction from the game recordings took place between 8 September 2023 and 16 March 2024. This sample represents about 14,400 minutes of play. The matches were studied using video available on television retransmission. In cases where the video quality was too low or the angle made the data analysis impossible, the sample was excluded.

2.2 Studied criteria

The various HIA1s examined were first classified as either positive or negative HIA1s by the local medical officer. For each HIA1, the following impact parameters were identified

- the area of impact on the player's head (Figure 1),
- the type of contact,
- the movement of the neck during contact.

In addition to examining these criteria, clustering was performed to differentiate between positive and negative HIAs.

Then, the match criteria were analyzed alongside the demographics of the suspected concussed player, such as age, height, weight and body mass index. Those of the other players involved were also taken into account if they influenced the impact. Finally, the characteristics of the tackle, such as the date, the phase of the game and the role of the player, were taken into account.

T-tests and Kruskal-Wallis tests were used to analyzed the statistical significance of the different parameters on the outcome of the HIA with a significance threshold set at $p < 0.05$.

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3. Results and discussion

3.1 Collected data

Only one operator was responsible for the analysis and the detection of HIA1 events depended on the field doctor. 162 HIA1s were detected and 61.1% were confirmed positive; 130 cases had complete data.

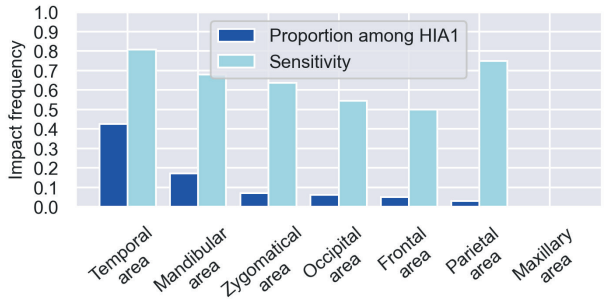

Figure 1. Distribution of HIA1-positive for the different contact zones and sensitivity of the medical decision.

3.2 Impact Parameters

Looking at the area of impact (Figure 1), the temporal and mandibular areas appear to be important indicators of concussion risk. The temporal region of the head represented about 53% of all HIA1 positive cases. For this specific area, the sensitivity of the medical decision, defined as the proportion of players who went for HIA1 and ended up positive, was about 81%. Our findings are consistent with the literature, as Tucker *et al.* 2017 identified these two areas as the most common sources of HIA1.

Regarding the type of impact, Table 1 shows that head-shoulder impact (27%) is the most common, closely followed by head-head impact (22.7%).
For the main cervical motion, rotation accounted for 76.0% of positive HIAs with a sensitivity of 77.0%. Extension accounted for 8.0% (sensibility of 40.0%), flexion for 14.7% (sensibility of 78.6%). Rotation is the main movement associated with HIA1 detected events as for HIA1-positive.
Thus, a movement that combines rotation and head-to-head or head-to-shoulder contact in the temporal region appears to be a high indicator of concussion risk.

3.3 Demographic and characteristics parameters

The average age of the affected player population was 27.60 +/- 4.06 years, with a height of 186.22 +/- 7.83 cm, a weight of 102.99 +/- 15.91 kg and a body mass index of 29.61 +/- 4.52 kg/m². The other player involved in contact had an age of 27.79 +/- 3.65 years, a height of 187.37 +/- 6.73 cm, a weight of 104.98 +/- 13.84 kg and a body mass index of 29.87 +/- 3.45 kg/m².
No significant differences were found between the groups of players. The distribution of the population corresponds to that previously reported.
Looking to the HIA outcome, the analysis showed only a statistical influence of the weight of the other player involved ($p < 0.05$) and a highest sensitivity for the second half-time ($p < 0.05$). In contrast to Dec, Kelly and Gilman, 2020, our study found no effect of age on the occurrence of positive HIA.

Table 1. Distribution of impacts linked to their nature.

Nature of impact	Head-Shoulder	Head-Head	Head-Hip	Head-Elbow
Proportion (%)	27.3	22.7	20.4	12.5
Sensitivity (%)	64.9	69.0	75.0	61.1
Nature of impact	**Head-Knee**	**Head-Ground**	**Head-Flank**	**Head-Foot**
Proportion (%)	9.1	3.4	3.4	1.1
Sensitivity (%)	100.0	60.0	60.0	100.0

4. Conclusions

Our study shows that the type of contact (head-head or head-shoulder), the area of impact (temporal) and the movement induced in the head-neck complex (axial rotation) are good predictors of concussion risk. The weight of the other players involved also plays an important role in the risk, which will lead to future studies looking at kinetic energy.
These results are also important for the development of models to better understand the phenomenon at the origin of sports-related concussion.

Conflict of Interest Statement

The study does not raise any conflicts of interest.

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