Head Impact Exposure in Junior and Adult Australian Football Players

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This study measured and compared the frequency, magnitude, and distribution of head impacts sustained by junior and adult Australian football players, respectively, and between player positions over a season of games. Twelve junior and twelve adult players were tracked using a skin-mounted impact sensor. Head impact exposure, including frequency, magnitude, and location of impacts, was quantified using previously established methods. Over the collection period, there were no significant differences in the impact frequency between junior and adult players. However, there was a significant increase in the frequency of head impacts for midfielders in both grades once we accounted for player position. A comparable amount of head impacts in both junior and adult players has implications for Australian football regarding player safety and medical coverage as younger players sustained similar impact levels as adult players. The other implication of a higher impact profile within midfielders is that, by targeting education and prevention strategies, a decrease in the incidence of sports-related concussion may result.

1. Introduction

Australian football (AF) is a contact, invasion game [1] combining athleticism with speed, necessitating skillful foot and hand passing [2] with aggressive tackling and sudden collisions between players and the ground [1, 3]. These collisions have the potential to result in head impacts that may lead to sports-related concussion (SRC), a mild traumatic brain injury associated with a range of symptoms, including headache and impaired memory [4, 5].

The SRC incidence rate for adults in AF (games and training) has been documented at 0.5 (95% CI: 0.4 to 0.7) per 1,000 participation hours and, in games only, it is 1.2 (95% CI: 0.8 to 1.7) per 1,000 game hours [6]. In the 9- to 17-year-old group the overall incidence rate has been reported at 0.6 (95% CI: 0.2 to 1.0) per 1,000 Athlete Exposures (A-E) with the older group (ages 14–17) recording 0.8 (95% CI: 0.1 to 1.5) per 1,000 A-E [7].

A recent study [8] measured the frequency, magnitude, and distribution of head impacts in senior AF players that revealed an average of 213 impacts per player for the season resulting in 29 impacts per player per match. The quantification of head impacts in sport is documented in the literature using a variety of devices. For example, mouthguard or head-mounted sensors (XPatch; X2Biosystems, USA) have documented head impacts in rugby union [9, 10], rugby league [11], collegiate wrestling [12], and AF [8]. This data has enabled the development of analytical risk functions [13–16], concussion risk curves [14], and risk weighted exposure metrics [17], further assisting in the identification of athletes at risk of SRC.
2. Material and Methods

2.1. Participants and IRB. A prospective observational cohort study was conducted in junior and senior AF players during games over the course of the 2016 season. A total of 12 juniors (18 ± 0.7 yr.; 183.5 ± 6.6 cm and 79.1 ± 6.9 kg) and 12 adults (21 ± 2.2 yr.; 187.4 ± 7.3 cm; 81 ± 7.7 kg) players agreed to participate and were enrolled in the study. These players consisted of 8 forwards (5 juniors, 3 adults); 8 midfielders (3 juniors, 5 adults); and 8 defenders (4 juniors, 4 adults). The ruck position players (3 juniors) were imbedded with the forward position as they move into the forward line when not competing in ruck contests. Consent was obtained from the players before enrolling in the study. The researchers' university ethics committee approved all procedures (MUHREC 2016/012). The participating teams and players provided approval prior to commencing the study.

2.2. Impact Testing. Participants wore a skin-mounted impact sensor (XPatch, X2 Biosystems, USA) that was fitted behind the right ear over the mastoid process using adhesive patch, as per manufacturer's instructions, and secured with a clear skin dressing. This application and data extraction were piloted successfully during the 2015 season using Injury Management Software (IMS) (X2 Biosystems) [11].

The sensor contained a low-power, high-g triaxial accelerometer with 200g maximum per axis, and a triaxial angular rate gyroscope to capture six degrees of freedom for linear and rotational time history acceleration of the heads center of gravity for all impacts that occurred during games. The time history incorporated three axes (x, y, z) of acceleration and velocity. While upright these planes describe the medial-lateral, anterior-posterior, and vertical acceleration and deceleration. The IMS enabled the raw data to be transformed to the approximate head center of gravity by using a rigid-body transformation for linear acceleration and a 5-point stencil for rotational acceleration [9, 22]. The biomechanical measures of head impact severity consisted of impact duration (ms), linear acceleration (g), and rotational head acceleration (rad/s²). Resultant linear acceleration is the rate of change in velocity of the estimated center of gravity of the head attributable to an impact and the associated direction of motion of the head [23]. Resultant rotational acceleration is the rate of change in rotational velocity of the head attributable to an impact and its direction in a coordinate system with the origin at the estimated center of gravity of the head [23]. False impacts were removed by the X2Biosystems proprietary “de-clacking” algorithm [9]. Impacts with a resultant linear acceleration of <10g were removed. The remaining impacts were downloaded and time-filtered to include only those impacts that occurred during game participation.

Head impact exposure including frequency, magnitude, and location of impacts were quantified using previously established methods [24, 25]. The impact variables were not normally distributed (Kolmogorov-Smirnov; \( p < 0.001 \)). Three measures of impact frequency were computed for each player: player impacts, the total, median, 25th–75th interquartile range (IQR), and the 95th percentile of head impacts recorded for a player during all the games observed, player impacts.
group impacts, the total, median [IQR], and the 95th percentile of impacts recorded for each of the player groups (forwards, midfielders, and backs) during all games observed, and impacts per game, the total, median [IQR], and the 95th percentile of head impacts recorded for a player during all the games observed.

Player head impact exposures were assessed utilizing previously published levels for injury tolerance (linear > 95g and rotational acceleration > 5,500 rad/s²), impact severity (linear mild < 66g, moderate 66–106g, severe > 106g), and rotational acceleration (mild < 4,600 rad/s², moderate 4,600–7,900 rad/s², severe > 7,900 rad/s²) [26–31].

Two additional risk equations were included in the analysis of the head impact exposure data. The Head Impact Telemetry Severity profile (HITSP) [32] is weighted composite score including linear and rotational acceleration, impact duration, and impact location. The Risk Weighted Exposure Combined Probability (RWECP) [17] is a logistic regression equation and regression coefficient of injury risk prediction of an injury occurring based on previously published analytical risk functions. RWECP combines resultant linear and rotational acceleration to elucidate individual player and team-based head impact exposure. The HITSP and RWECP were analyzed by player position and player group impacts utilizing a Friedman repeated measures ANOVA on ranks. A post hoc analysis with Wilcoxon signed-rank tests was conducted with a Bonferroni correction applied if any significant differences were observed.

Resultant peak linear and rotational acceleration and impact locations (front, back, side, and top) between player positions were assessed utilizing a Friedman repeated measures ANOVA on ranks. A post hoc analysis with a Wilcoxon signed-rank tests was conducted with a Bonferroni correction applied if any significant differences were observed. A one sample chi-squared ($\chi^2$) test and risk ratio (RR), with 95% confidence intervals (CI), were utilized to determine whether the observed impact frequency was significantly different from the expected impact frequency. Statistical significance was set at $p < 0.05$.

### 3. Results

A total of 1,609 impacts were recorded over the duration of the study resulting in an average of 60 ± 36 impacts per player per season (Table 1). Peak linear acceleration ranged from 10g to 158.8g with a median and 95th percentile value of 15.3g and 45.8g, respectively. Rotational acceleration ranged from 52.3 rad/s² to 22,458.0 rad/s² with a median value of 2,729.8 rad/s². As a result, the HITSP varied from 10.7 to 207.5 with a median value of 15.5. Junior players had a median resultant peak linear and rotational acceleration of 15.1g and 2,741.7 rad/s². Senior players had a median resultant peak linear and rotational acceleration of 15.7g and 2,757.4 rad/s².

Midfielders recorded more impacts than defenders for both the junior (RR: 1.6 [95% CI: 1.4–1.8]; $p = 0.0017$) and senior teams (RR: 1.3 [95% CI: 1.1–1.5]; $p < 0.0001$) (see Table 1). Junior midfielders recorded a higher median peak linear acceleration (15.5g) than defenders ($\chi^2 = 34.0$; $p < 0.0001$; $z = -2.01$; $p = 0.0443$). Senior forwards recorded a lower median peak linear acceleration (15.8g) than midfielders ($\chi^2 = 28.9$; $p < 0.0001$; $z = -2.29$; $p = 0.0221$). Senior midfielders recorded a higher median resultant peak linear acceleration (16.9g) than junior midfielders (15.5g; $\chi^2 = 16.5$; $p < 0.0001$; $z = -2.03$; $p = 0.0421$).

The side of the head was the most common impact site for total (37.4%) and senior (43.4%) players but the front of the head (37.9%) was the most common impact site for juniors (Table 2). Juniors recorded noticeably more impacts to the front of the head (RR: 1.2 [95% CI: 1.0 to 1.4]; $p = 0.0366$) and less impacts to the side of the head (RR: 1.4 [95% CI: 1.2–1.5]; $p = 0.0002$) than seniors. For total impacts the front of the head recorded noticeably higher resultant peak rotational acceleration (3,278.8 rad/s²) than the top of the head (2,310.3 rad/s²; $\chi^2 = 14.2$; $p = 0.0002$; $z = -2.9$; $p = 0.0036$). As a result, the front of the head recorded a higher HITSP (15.6 versus 14.6; $\chi^2 = 4.5$; $p = 0.0339$; $z = -2.1$; $p = 0.0379$) and RWECP (0.0012 versus 0.0005; $\chi^2 = 15.5$; $p = 0.0004$; $z = -2.7$; $p = 0.0077$) when compared with the top.

Less than 1% of peak resultant linear impacts greater than 95g for junior, senior, and total impacts were recorded (Table 3). The majority of peak resultant linear impacts were recorded in the mild (<66g) category for juniors (95.4%) and seniors (96.7%). The majority of peak resultant rotational acceleration was in the mild (<4,600 rad/s²) severity for juniors (73.2%) and seniors (71.0%). There were more severe HITSP impacts recorded for seniors (RR: 1.8 [95% CI: 1.0–3.2]; $p = 0.0461$) when compared with seniors.

#### 4. Discussion

This study compared head impact mechanics at two levels of play and the differences in impacts between positions. It is important to stress that it remains unknown as to how many head impacts and what intensity impact might lead to SRC. The severity of brain injury among young athletes is also reported to be due to multifactorial components and not solely impact forces [23, 33].

This study adds to the current literature as it recorded the magnitude, frequency, and distribution of impacts to the head for different positions in AF players participating at two distinct levels: junior and senior. A recent study [8] established measures of frequency, magnitude, and distribution of head impacts in adult-level AF and this study furthers these findings by contrasting two age groups.

### 4.1 Differences between Senior and Junior Players.

In this study, there were similar results between the two levels of play in median linear and rotational acceleration with the senior players recording slightly higher values in both areas. This is not surprising due to the increased speed, game duration, and players size in senior players [34, 35]. Although the age levels did not vary substantially and are representative of the cohorts, this remains problematic as the differences in measurements were negligible and potentially place the younger cohort at increased risk of SRC. The Kennard principle [36] states that a young brain is more adaptive
Table 1: Impacts to the head greater than 10\(g\) for total impacts recorded, impacts by total, junior, and senior level teams and by forwards midfielders and defenders for each level of participation in an amateur Australian Football League team over a season of matches. Data are presented as median [interquartile range] and 95th percentile for total impacts, impacts per player position group, impact duration (ms), resultant linear and rotational acceleration, head impact telemetry severity profile, and risk weighted exposure combined probability.

|                  | Total impacts \(n=\) | Per player per match season | Per player per match | Impact duration (ms) | PLA (\(g\)) | PRA (\(\text{rad/s}^2\)) | HIT\(_{SP}\) | RWE\(_{CP}\) |
|------------------|----------------------|-----------------------------|----------------------|--------------------|-------------|--------------------------|------------|-----------|
|                  |                      | Mean ± SD                  | Mean ± SD            | Median [IQR]       | Mean ± SD   | Median [IQR]             | Mean ± SD  | Mean ± SD |
| Total            | Combined             | 1,609                      | 60 ± 36              | 8 ± 8              | 10.9 ± 7.9 | 15.3 [11.9–23.3]         | 45.8 [1,680.0–4,784.3] | 9,592.9 [13.2–20.8] | 15.5 [13.2–20.8] | 41.7 [0.0003–0.0060] | 0.9874 |
|                  | Junior               | 861                        | 62 ± 39              | 7 ± 9              | 10.4 ± 1.6 | 15.1 [11.9–22.2]         | 45.7 [1,712.8–4,648.4] | 9,644.5 [12.6–21.2] | 15.3 [12.6–21.2] | 46.8 [0.0003–0.0052] | 0.3969 |
|                  | Senior               | 748                        | 58 ± 35              | 8 ± 7              | 11.4 ± 8.2 | 15.7 [11.9–24.2]         | 46.8 [1,652.6–4,915.7] | 9,556.1 [13.0–21.2] | 15.4 [13.0–21.2] | 39.0 [0.0003–0.0067] | 0.3862 |
| Junior           | Forwards             | 228\(^bc\)                | 57 ± 17              | 7 ± 6              | 10.4 ± 6.7 | 14.5 [11.7–21.6]         | 40.5 [1,511.3–4,760.5] | 9,427.4 [11.7–26.1] | 15.4 [11.7–26.1] | 98.0 [0.0002–0.0061] | 0.3484 |
|                  | Midfielder           | 356\(^ae\)                | 71 ± 60              | 8 ± 12             | 11.0 [12.0–22.5] | 47.3 [1,718.5–4,808.0] | 10,672.9 [12.7–20.4] | 15.2 [12.7–20.4] | 46.8 [0.0003–0.0063] | 0.6233 |
|                  | Defender             | 277\(^ab\)                | 55 ± 30              | 8 ± 5              | 9.6 [11.9–22.2] | 14.8 [11.9–22.2] | 39.5 [1,848.2–4,430.0] | 8,406.2 [12.9–21.6] | 42.7 [0.0003–0.0040] | 0.2035 |
| Senior           | Forwards             | 236\(^b\)                | 59 ± 27              | 9 ± 7              | 10.6 [11.7–24.3] | 45.2 [1,623.5–5,235.5] | 9,766.7 [11.6–22.1] | 14.2 [11.6–22.1] | 46.0 [0.0003–0.0101] | 0.4802 |
|                  | Midfielder           | 305\(^a\)                | 76 ± 54              | 11 ± 11            | 13.1 [12.5–26.5] | 52.8 [1,744.6–5,068.2] | 9,617.2 [13.1–21.2] | 15.1 [13.1–21.2] | 43.1 [0.0003–0.0082] | 0.4660 |
|                  | Defender             | 207\(^b\)                | 41 ± 12              | 8 ± 7              | 10.9 [11.9–21.4] | 43.1 [1,569.7–4,500.7] | 8,599.6 [13.6–20.6] | 15.8 [0.0003–0.0042] | 0.2701 |

\([IQR] = \) interquartile (25th to 75th) percentile; 95% = 95th percentile; PLA (\(g\)) = peak linear acceleration in gravitational force (\(g\)); PRA (\(\text{rad/s}^2\)) = peak rotational acceleration in radians/second\(^2\); HIT\(_{SP}\) = Head Impact Telemetry Severity Profile; RWE\(_{CP}\) = Risk Weighted Exposure Combined Probability; significant difference (\(p < 0.05\)) compared to \(^a\)forward; \(^b\)midfielder; \(^c\)defender; \(^d\)junior; \(^e\)senior.
Table 2: Impacts to the head greater than 10\(g\) by impact location for total impacts, impacts recorded by junior and senior players in an amateur Australian Football League team over a season of matches.

| Location | \(n = \) | % | Duration ms ± SD | PLA (\(g\)) | Median [IQR] | 0.95 | PRA (rad/s^2) | Median [IQR] | 0.95 | HITSP | Median [IQR] | 0.95 | RWECP | Median [IQR] | 0.95 |
|----------|----------|---|-----------------|-------------|--------------|------|--------------|--------------|------|-------|--------------|------|--------|--------------|------|
| Total    |          |    |                 |             |              |      |              |              |      |       |              |      |        |              |      |
| Front    | 563^dfe | 35.0 | 11.0 ± 7.6      | 16.2 [12.2–24.6] | 44.8 | 3,278.8^dfe [2,050.0–5,322.4] | 9,684.3 | 15.6^dfe [13.0–21.4] | 39.2 | 0.001^de [0.0004–0.0085] | 0.5046 |
| Back     | 368^ce  | 22.9 | 10.2 ± 7.6^e    | 15.5 [11.7–23.5] | 42.4 | 2,705.7 [1,343.1–4,873.5] | 8,832.4 | 14.6 [11.5–23.0] | 46.0 | 0.0007 [0.0002–0.0065] | 0.2269 |
| Side     | 602^d^f | 37.4 | 11.1 ± 8.1^f    | 14.9 [11.8–21.9] | 51.3 | 2,389.9^f [1,517.6–4,294.6] | 9,728.9 | 15.4 [13.6–20.2] | 42.3 | 0.0006 [0.0002–0.0037] | 0.4449 |
| Top      | 76^e    | 4.7  | 13.0 ± 10.2     | 16.0 [11.8–22.1] | 48.2 | 2,310.3^e [1,469.0–4,458.2] | 11,139.3 | 14.6^e [12.5–19.4] | 53.6 | 0.0005^e [0.0002–0.0042] | 0.7728 |
| Juniors  |          |    |                 |             |      |              |              |      |       |              |      |        |              |      |
| Front    | 326^bcdef | 37.9 | 10.8 ± 7.3      | 15.8 [12.1–23.9] | 44.0 | 3,115.8^bcdef [2,062.2–5,213.4] | 9,640.6 | 14.6 [11.4–20.7] | 48.0 | 0.001^def [0.0004–0.0079] | 0.5156 |
| Back     | 215^cef  | 25.0 | 10.2 ± 7.8      | 15.5 [11.8–22.9] | 40.3 | 2,705.7 [1,348.7–6,653.7] | 8,839.1 | 14.5 [12.0–23.2] | 47.1 | 0.0007^c [0.0002–0.0047] | 0.2247 |
| Side     | 277^cde  | 32.2 | 10.0 ± 7.1      | 14.2 [11.8–20.5] | 49.1 | 2,450.2^cde [1,520.7–3,944.1] | 10,267.7 | 15.4 [13.5–19.9] | 45.1 | 0.0006^c [0.0002–0.0027] | 0.5151 |
| Top      | 43^de   | 5.0  | 11.4 ± 9.9      | 16.1 [11.7–21.1] | 44.0 | 2,302.9 [1,562.9–3,823.5] | 10,491.6 | 15.6 [12.9–19.2] | 47.9 | 0.0005^c [0.0003–0.0021] | 0.5334 |
| Seniors  |          |    |                 |             |      |              |              |      |       |              |      |        |              |      |
| Front    | 237^pgdef | 31.7 | 11.2 ± 8.0^f    | 15.2 [11.7–22.8] | 46.0 | 2,334.9 [1,481.9–4,363.1] | 10,158.3 | 15.3 [13.4–20.4] | 35.6 | 0.0005 [0.0002–0.0039] | 0.5140 |
| Back     | 153^cdef | 20.5 | 10.2 ± 7.2^f    | 15.3 [11.7–24.6] | 43.3 | 2,711.6 [1,302.2–5,187.3] | 8,841.5 | 14.2 [10.5–23.4] | 46.3 | 0.0008 [0.0002–0.0080] | 0.2271 |
| Side     | 325^cdef | 43.4 | 12.0 ± 8.7      | 14.6 [11.6–20.7] | 53.2 | 2,198.3 [1,441.5–4,061.1] | 9,028.1 | 14.9 [13.3–18.8] | 40.4 | 0.0005 [0.0002–0.0029] | 0.3909 |
| Top      | 33^de   | 4.4  | 14.8 ± 10.3^e   | 16.0 [12.2–32.8] | 58.0 | 2,760.9 [1,110.3–4,916.3] | 12,029.1 | 13.5 [11.8–23.9] | 67.8 | 0.0008 [0.0002–0.0105] | 0.9079 |

Data are presented as mean (±SD) for impact duration (ms) and median [IQR] and 95th percentile for total impacts, juniors, seniors, resultant linear, and rotational acceleration, Head Impact Telemetry Severity Profile, and Risk Weighted Exposure Combined Probability. IQR: = interquartile (25th to 75th) percentile; 95%: = 95th percentile; PLA (\(g\)): peak linear acceleration in gravitational force (\(g\)); PRA (rad/s^2) = peak rotational acceleration in radians per second; HITSP: = Head Impact Telemetry Severity Profile; RWECP: = Risk Weighted Exposure Combined Probability; significant difference (\(p < 0.05\)) compared to \(^a\)junior; \(^b\)senior; \(^c\)front; \(^d\)back; \(^e\)side; \(^f\)top.
Table 3: Impacts to the head greater than 10g by injury tolerance, injury severity for resultant linear and rotational accelerations, Head Impact Telemetry Severity Profile and Risk Weighted Exposure Combined Probability for total impacts, impacts recorded by junior, senior, and total in an amateur Australian Football League team over a season of matches.

| Injury tolerance | Junior | Senior | Total |
|------------------|--------|--------|-------|
| >95g             | 2 (0.2)| 6 (0.8)| 8 (0.5)|
| >5500 rad/s²     | 153 (17.8)| 148 (19.8)| 301 (18.7)|

| Injury severity (linear) | Junior | Senior | Total |
|--------------------------|--------|--------|-------|
| <66g                     | 821 (95.4)| 723 (96.7)| 1,544 (96.0)|
| 66–106g                  | 31 (3.6)| 18 (2.4)| 49 (3.0)|
| >106g                    | 9 (1.0)| 7 (0.9)| 16 (1.0)|

| Injury severity (rotational) | Junior | Senior | Total |
|-------------------------------|--------|--------|-------|
| <4600 rad/s²                 | 630 (73.2)| 531 (71.0)| 1,161 (72.2)|
| 4600–7900 rad/s²             | 155 (18.0)| 150 (20.1)| 305 (19.0)|
| >7900 rad/s²                 | 76 (8.8)| 67 (9.0)| 143 (8.9)|

| HITSP | Junior | Senior | Total |
|-------|--------|--------|-------|
| <21   | 627 (72.8)| 554 (74.1)| 1,181 (73.4)|
| 21–63 | 199 (23.1)| 177 (23.7)| 376 (23.4)|
| >63   | 35 (4.1)| 17 (2.3)| 52 (3.2)|

| RWECP | Junior | Senior | Total |
|-------|--------|--------|-------|
| <0.2500 | 788 (91.5)| 696 (93.0)| 1,484 (92.2)|
| 0.2500–0.7500 | 45 (5.2)| 29 (3.9)| 74 (4.6)|
| >0.7500 | 28 (3.3)| 23 (3.1)| 51 (3.2)|

Data are presented as number of impacts and percentage of impacts recorded. rad/s²: radians per second; HITSP: Head Impact Telemetry Severity Profile; RWECP: Risk Weighted Exposure Combined Probability; significant difference (p < 0.05) compared ^ junior, ^ senior.

4.2. Differences between Playing Positions. The results at various playing positions showed midfields sustaining more impacts per player, per game over the course of the data collection period for junior and senior players. This study supports previous research [11], where it was also reported that AF midfields experienced significantly more impacts per player. Additionally, the junior midfields recorded significantly (p = 0.0443) higher median peak linear acceleration (15.5g) than defenders with the senior midfields having significantly higher (p = 0.0221) median peak linear acceleration than forwards. Overall, senior midfields recorded a higher median resultant peak linear acceleration (16.9g) than junior midfields (15.5g; p = 0.0421). There is no data reporting which player position reports the highest level of SRC; however, why the midfield position in this study recorded more impacts needs to be examined in future research.

4.3. Association between Head Impacts and the Risk of Developing Sports-Related Concussion. This study included the RWE that allows identification of the variability of exposure from linear and rotational acceleration [17]. In order to accurately predict the risk of SRC, both linear and rotational acceleration should be accounted for to determine the concussion risk [17]. The RWECP enabled this concussion risk prediction to be undertaken. By recording the RWECP of individual players and player groups and for the sport [10], the resulting values may assist in identifying players with a potential cumulative exposure resulting in SRC. Previous studies in high school American football (14 to 18 yr.), Australian Football, under-11 junior rugby league, and collegiate wrestling [8, 11, 12, 17] have reported RWECP. The RWECP values were evaluated by risk values of 25%, 25% to 75%, and >75% with the results showing similar mean values of 0.0008 for both junior and senior levels of participation. However, junior participants had a slightly higher percentage of impacts in the 0.2500–0.7500 (5.2 versus 3.9) and >0.7500 (3.3 versus 3.1) range than senior participants which again highlights the potential need for a change in current practice in AF that reflects potential increased risk of injury at a junior level. Player positions showed similar results between the three groups for the juniors but midfields in the senior group recorded slightly higher RWECP values.

4.4. Informing Changes to Clinical Practice. Although RWECP were relatively small in both groups compared to American football (0.497) [17], AF (0.0003) [8] and junior rugby league (0.001) [10], the concern is the comparable level of the RWECP across junior and senior participants that places the juniors at a similar SRC risk as senior participants. Therefore, player safety at the junior level is one area that may be addressed with attention to SRC. The Australian Football League (AFL) has been proactive in SRC and first developed its community-AF concussion guidelines in 2011 based on the 2008 International Consensus Statement on Concussion in Sport [39]. The results of this study also indicate that current guidelines on appropriate medical cover for AF do not reflect the risks seen in previous research on SRC and this research on head impacts where senior games have higher levels of medical cover than junior levels.
Equipment and structural changes to the game at the junior level could be considered; however, current evidence does not support any protective effect for SRC from many of the soft-shell helmets available [40, 41]. Given the lack of effectiveness of headgear in protecting against SRC, other potential preventive solutions need to be measured for effectiveness. For example, future research could consider the effectiveness of training exercises for body-contact, neck strengthening, safe tackling, and reviewing the enforcement of games rules that all could be valuable strategies to reduce dangerous play that leads to injury [6]. Specifically, given the increased exposure seen in midfielders, targeting education strategies at this group may translate to decreases in the incidence of SRC. Our results support further inquiry as to when, why, and how SRCs occur to elucidate potential encompassing preventive measures.

4.5. Study Limitations. There are a several limitations in the study including data collection over a full season for each player and a small sample size. Furthermore, SRC assessments conducted by the team physiotherapist were not included in the analysis. The XPatch has undergone some reported validation studies and been compared with the Head Impact Telemetry System (HITS); however the results have varied [22, 42]. As a result of these different findings, the impact variables reported in this study should be assumed to have some form of error that is dependent on impact conditions and the measure of interest and the variability tested [29, 43]. There are no consistent reliability studies for the XPatch and the resultant impact variables that are recorded and the results presented in this study should be interpreted with some caution.

5. Conclusions

Obtaining head impact mechanics with the use of accelerometer sensors allows comparison between various levels of play and positions in AF. This is vital as those in the younger levels, whose brains are still developing, are potentially more susceptible to injury. In this study, the players at the junior level recorded similar levels of impact to those in the adult level with midfielders suffering the most impacts per match. Due to this, future research needs to address safety issues at the lower levels to ensure less traumatic impacts to the younger players and reviews of current practice in medical coverage for AF should be considered.

Conflicts of Interest

The authors report no conflicts of interest associated with the research contained within this manuscript.

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