Therefore, the results of this study highlight the difficulty of concussion recognition, at least with youth and reported symptoms, thus supporting the need for evaluation tests such as the King-Devick and the Sport Concussion Assessment Tool (SCAT). Future studies may want to include head injury incidence; head impact frequency; acceleration magnitude; impact location, signs and symptoms and concussion assessment evaluations.

Limitations

A health care provider was not present at the games, therefore concussion evaluations were not conducted and the two groups were established based on self-report incidences without a clear diagnosis of SRC. A further limitation to this study was not having multi-angled video footage of the game to enable correlation between the head impacts recorded and physical contacts that occurred during game participation. As such, it was not established whether the impacts were from body contact or from contact with the ground and hence, the results must be interpreted accordingly. Future head impact studies should use high quality multiple angled cameras in an elevated position to enable verification of the impacts recorded.

The XPatch has been reported to have several noteworthy limitations. The risk of device malfunction, premature battery discharge and time stamp malfunction can lead to some degree of data loss (Eckner, et al., 2018). No XPatch sensors utilised in this study were identified to have had a malfunction but the possibility does exist and thus poses a limitation on the data reported. Moreover, the accuracy of the linear and rotational acceleration measurements has been reported to vary widely under different testing environments (Nevins et al., 2015; Siegmund et al., 2015; Wu et al., 2016). The PRA was found to underestimate in a study utilising a non-helmeted anthropometric test device but, when utilising cadaveric model with a helmet, it was reported that the XPatch overestimated PLA(g) and PRA(deg/s^2) when compared with a reference device mounted at the foramen magnum (Siegmund et al., 2015). In addition, the cadaveric model also reported a significant difference in impact location between the XPatch and the reference sensor for forehead impacts but when tested on side and rear impacts the agreement was better (Siegmund et al., 2015). As the XPatch is adhered to the side of the head over the mastoid process there is the potential problem of dermal artifact that can occur with imperfect coupling between the skin patches and the skull causing inaccuracy (Wu et al., 2016). As well there may have been some measurement error resulting from relative motion between the skin at the mastoid process and the skull which may have amplified the resultant head impact accelerations.

Another concern that has been reported for the XPatch is the proprietary algorithm utilised to remove errant events from the recorded data set. If these erroneous events are not appropriately identified and removed this can lead to an elevated false-positive rate for the XPatch dataset (Cortes et al., 2017; Press and Rowson, 2017). As the XPatch do not have the ability to detect when they are worn by the athlete there is the risk that the algorithm may include false-positive impacts in the data set recorded from any time the device is turned on until they are switched off (Eckner, et al., 2018). Conversely, there is the potential for the algorithm to identify valid impacts as false negative and exclude these from the data set (Eckner, et al., 2018). The classification of false-positive and false-negative impacts has the potential to influence impact counts and impact magnitude calculations, especially if the rate of false-positive and/or false-negative rates vary over the range of impact magnitudes (Eckner, et al., 2018). As a result, the number of impacts, impact magnitudes and impact locations reported in this study may vary when compared with studies recorded by other impact-sensing devices (Eckner, et al., 2018). Therefore the results of this study should be interpreted cautiously. In an endeavour to reduce the risk of false-positive impacts, all the XPatches were calibrated to the correct time and following the downloading of the dataset, these were manually reviewed and any impacts outside of the game start and stop times were removed from the data set.

Conclusion

This study established the frequency, magnitude, and distribution of head impacts sustained by youth AF players over a season of games. The results showed similar measurements to players in the older junior- (aged 17-19) and senior-leagues (20+). Furthermore, players who reported sustaining a direct or indirect impact during a games had similar measurements to those who did not, thus highlighting the difficulty of concussion recognition, at least with youth. Future research may need to establish the relationship between concussion-like symptoms in the absence of an impact and in relation to concussion evaluation assessments such as the King-Devick and the SCAT.

Acknowledgements

The authors have no conflicts of interest to declare. All experiments comply with the current laws of the country.

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Received: 24 July 2018 / Accepted: 25 August 2018 / Published (online): 01 December 2018

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Key points

- 13- 14 year old Australian Football players experience approximately 5 head impacts per-player per-game.
- The magnitude, peak linear rotation and peak rotational acceleration of these head impacts are comparable to those of Australian football players 17 years and older.
- Given the age of these players this study highlights the need for increased awareness of head impacts and concussion in youth, community level Australian football

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