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Computational modelling of traumatic brain injury in elite Rugby Union

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Abstract

Introduction

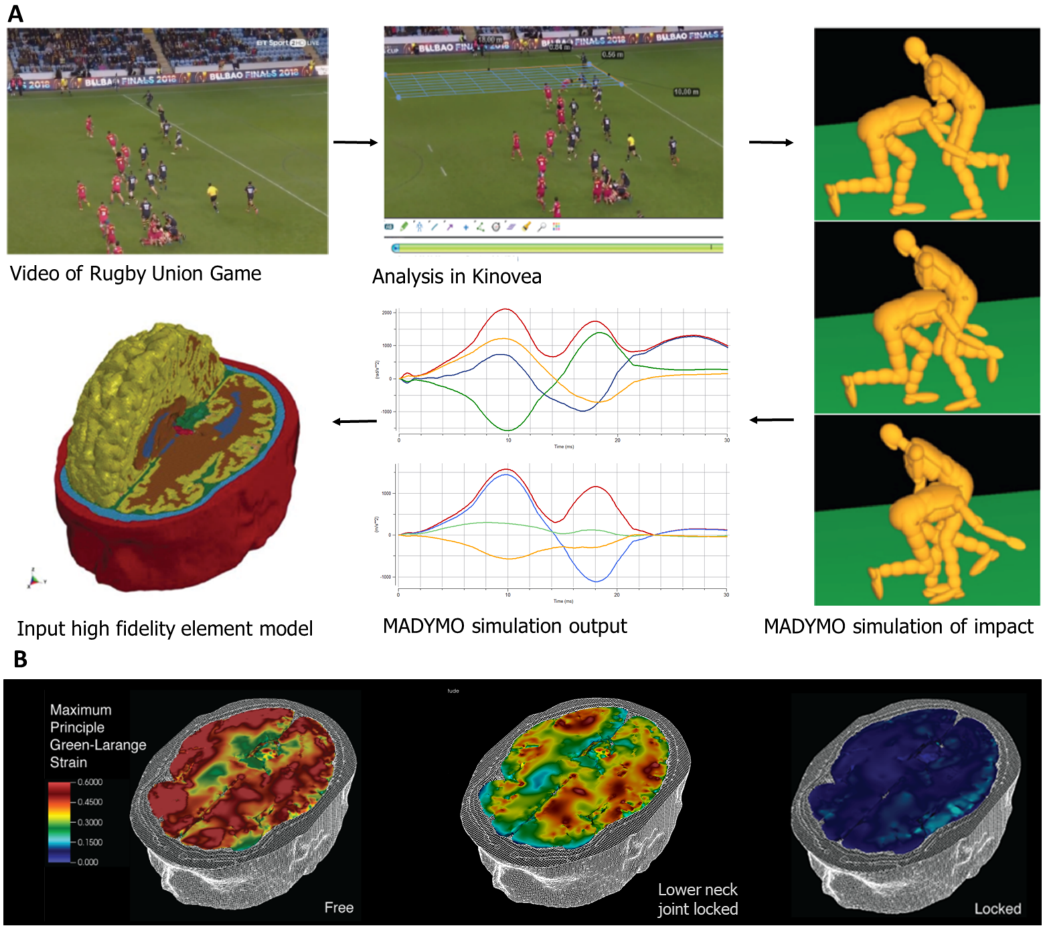
Collisions in contact sports may result in traumatic brain injury (TBI) and understanding how the biomechanics of impacts relates to TBI is key to improving the safety of games. Previous studies have used video analysis (1) and computational modelling to study head impacts in Rugby Union (2), showing the effects of body and head positioning and speed on risk of mild TBI. Here we present a new case study in Rugby Football Union using video analysis, multibody dynamics and high fidelity finite element analysis of TBI. Emerging evidence suggests neck strength training can reduce risk of head injury (3) and the focus of our initial study is on the effects of neck constraints on brain tissue deformation.

Methods

Video of a single Rugby Union tackle was analysed using Kinovea 0.8.26. A perspective based grid was overlaid on the video and calibrated using known distances to calculate the velocity of players at impact. Four camera angles were used to identify the direction of player movement, impact angle and location. The impact was then simulated using the multibody dynamics software MADYMO. The ellipsoid pedestrian model was selected which consists of 52 rigid bodies connected by kinematic joints. The neck is modelled by an ellipsoid with two free joints, at the lower neck (T1-C7) and at the upper neck (C1-Head). Four simulations with different conditions of the neck joints (locked or free) were performed and head linear and angular accelerations were recorded. With a high fidelity FE model of TBI (4) the contours of maximum principal Green-Lagrange strain maps were predicted.

Results

The video analysis and multibody simulations allowed us to accurately reconstruct the kinematics of the impacts (Fig A). Interestingly the neck conditions had a significant influence on the maximal strains within the brain. When both neck joints are fixed (neck locked) strains are significantly lower compared to the other three conditions, where one or both joints are completely free (Fig B).



A. Pipeline of video analysis and of the computational simulation.
B. Strain and strain rate contours within the brain calculated in different neck joint conditions.

Discussion

Fixing the neck joints significantly reduces head rotation about the neck joints, which explains why the strains were lower in this case than when one or more neck joints were free. This preliminary work highlights the importance of the neck constraint in TBI biomechanics of sporting collisions. This also demonstrates the need for using a higher fidelity neck model to investigate injuries related to sports impacts.

References

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