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Impact Location From Instrumented Mouthguard Kinematic Data In Rugby

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Abstract : Mild traumatic brain injury (mTBI) within non-helmeted contact sports is a growing concern due to the serious risk of potential injury. Extensive research is being conducted looking into head kinematics in non-helmeted contact sports utilizing instrumented mouthguards that allow researchers to record accelerations and velocities of the head during and after an impact. This does not, however, allow the location of the impact on the head, and its magnitude and orientation, to be determined. This research proposes and validates two methods to quantify impact locations from instrumented mouthguard kinematic data, one using rigid body dynamics, the other utilizing machine learning. The rigid body dynamics technique focuses on establishing and matching moments from Euler's and torque equations in order to find the impact location on the head. The methodology is validated with impact data collected from a lab test with the dummy head fitted with an instrumented mouthguard. Additionally, a Hybrid III Dummy head finite element model was utilized to create synthetic kinematic data sets for impacts from varying locations to validate the impact location algorithm. The algorithm calculates accurate impact locations; however, it will require preprocessing of live data, which is currently being done by cross-referencing data timestamps to video footage. The machine learning technique focuses on eliminating the preprocessing aspect by establishing trends within time-series signals from instrumented mouthguards to determine the impact location on the head. An unsupervised learning technique is used to cluster together impacts within similar regions from an entire time-series signal. The kinematic signals established from mouthguards are converted to the frequency domain before using a clustering algorithm to cluster together similar signals within a time series that may span the length of a game. Impacts are clustered within predetermined location bins. The same Hybrid III Dummy finite element model is used to create impacts that closely replicate on-field impacts in order to create synthetic time-series datasets consisting of impacts in varying locations. These time-series data sets are used to validate the machine learning technique. The rigid body dynamics technique provides a good method to establish accurate impact location of impact signals that have already been labeled as true impacts and filtered out of the entire time series. However, the machine learning technique provides a method that can be implemented with long time series signal data but will provide impact location within predetermined regions on the head. Additionally, the machine learning technique can be used to eliminate false impacts captured by sensors saving additional time for data scientists using instrumented mouthguard kinematic data as validating true impacts with video footage would not be required.

Keywords : head impacts, impact location, instrumented mouthguard, machine learning, mTBI
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