ABSTRACT

Background: Reports estimate that 1.6 to 3.8 million cases of concussion occur in sports and recreation each year in the United States. Despite continued efforts to reduce the occurrence of concussion, the rate of diagnosis continues to increase. The mechanisms of concussion are thought to involve linear and rotational head accelerations and velocities. One method of quantifying the kinematics experienced during sport participation is to place measurement devices into the athlete’s helmet or directly on the athlete’s head.

Purpose: The purpose of this research to determine the accuracy of a head mounted device for measuring the head accelerations experienced by the wearer. This will be accomplished by identifying the error in Peak Linear Acceleration (PLA), Peak Rotational Acceleration (PRA) and Peak Rotational Velocity (PRV) of the device.

Study Design: Laboratory study.

Methods: A helmeted Hybrid III 50th percentile male headform was impacted via a pneumatic ram from the front, side, rear, front oblique and rear oblique at speeds from 1.5 to 5 m/s. The X2 Biosystems xPatch® (Seattle, WA) sensor was placed on the headform's right side at the approximate location of the mastoid process. Measures of PLA, PRA, PRV from the xPatch® and Hybrid III were analyzed for Root Mean Square Error (RMSE), and Absolute and Relative Error (AE, RE).

Result: Seventy-six impacts were analyzed. All measures of correlation, fixed through the origin, were found to be strong: PLA $R^2 = 0.967 \ p<0.01$, PRA $R^2 = 0.933 \ p<0.01$, PRV $R^2 = 0.999 \ p<0.00$. PLA RMSE was 34%, RE 31.0% ± 14.0, and AE 31.1% ± 13.7. PRA RMSE was 23.4%, RE -6.7 ± 22.4 and AE 18.9% ± 13.8. PRV RMSE was 2.2%, RE 0.1 ± 2.2, and AE 1.8 ± 1.3.

Conclusion: Without including corrections for effect of skin artifact, the xPatch® produces measurements highly correlated with the gold standard yet above the average error of testing devices in both PLA and PRA, but a low error in PRV. PLA measures from the xPatch® system demonstrated a high level of correlation with the PLA data from the Hybrid III mounted data collection system.

Level of Evidence: 3

Key words: Concussion, head acceleration, head velocity