Head Kinematics and Physiological Effects of Repeated Soccer Heading

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Background

An estimated 1.6-3.8 million sports- and recreation-related concussions occur each year, and adolescents are particularly vulnerable to head injury and suffer longer recovery periods than adults. Furthermore, there is growing concern for the neurological effects of repeated head impacts that do not manifest into clinical symptoms. Previous studies have shown that repeated soccer heading caused immediate but transient decreases in neurocognitive performance, postural control, and ocular reflexes. However, these studies focus on adults and lack high-quality head kinematic data.

Objective

To quantify the adolescent head kinematics of frontal and oblique soccer headers using an instrumented mouthguard and assess changes in physiological function following a series of soccer headers compared to kicking control subjects.

Methods

Participants (active male and female soccer players aged 13-18) were randomly assigned to kicking control, frontal heading, or oblique heading groups as part of a randomized controlled trial (approved by the Children's Hospital of Philadelphia IRB). Participants completed a suite of neurofunction assessments including the Post-Concussion Symptom Inventory (PCSI), visio-vestibular exam (VVE) including near point of convergence, and pupillary light reflex (PLR) at three time points: immediately prior to, immediately after, and 16-72 hours after completing 10 soccer headers or kicks (control). Headers were performed with size 5 soccer balls projected at 11.2 m/s from a distance of 10 m. Head kinematic data were collected using the Prevent Biometrics boil-and-bite instrumented mouthguard at 3200 Hz using a 5 *g* recording threshold. Head kinematic data were compared between frontal and oblique groups using two-sample t-tests (α=0.05). Physiological data were compared using two-way repeated measures ANOVA across group and timepoint (α=0.05).

Results

Data were collected for 19 participants (17 male) randomized into control (n=8), frontal heading (n=6), and oblique heading (n=5) groups. Head kinematic analysis is based on the 104 evaluable sensor-recorded impacts from 110 headers. Frontal soccer headers resulted in significantly higher peak linear acceleration (18.3±1.8 *g*) compared to oblique headers (12.2±0.7 *g*, p=0.017), and oblique headers resulted in significantly higher peak angular velocity (frontal: 6.0±0.6 rad/s, oblique: 10.2±0.8 rad/s, p=0.002) but similar angular acceleration (frontal: 1285.6±192.2 rad/s^2, oblique: 1405.1±92.4 rad/s^2, p=0.613). For comparison to control subjects, both heading groups were combined. Control and heading subjects did not differ in baseline symptom PCSI scores (control: 0.9±2.1, heading: 3.1±3.4, p=0.372) or change in PCSI after heading at either timepoint (p=0.402). None of the components of the VVE nor any measures of the PLR differed between control and heading subjects at any time point (p>0.440).

Conclusions

Header impact direction influenced both linear and angular kinematics with frontal headers resulting in higher peak linear acceleration and oblique headers in higher peak angular velocity. The physiological effects of soccer heading were tested via multiple subjective and objective clinical assessments – e.g., subjective symptoms, semi-objective VVE, and objective PLR – demonstrating that a series of soccer headers did not leave a signature on brain function, in the acute time period. These data

provide high-quality soccer heading kinematic data comparing multiple impact directions, and future studies should investigate potential sex differences in physiological deficits.