Measurement of Head Motion Experienced During Open-Wheel Dirt Track Racing

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Introduction

Motorsports—particularly auto racing—are popular spectator sports in the United States, with millions of viewers annually.[1] By the nature of racing, participants experience high velocities and accelerations and risk collisions with barriers or other vehicles. There is limited literature on concussion incidence in auto racing, but one study estimated incidence to be 1.3 concussions per 1000 driver-races among professional drivers,[2] which is high relative to other sports (e.g., football, hockey).[3] Beyond concussion, literature suggests exposure to repetitive head impacts is associated with changes to the brain even without a clinically diagnosed concussion.[4] Head kinematics (i.e., head motion) experienced during auto racing have not been well described, especially at the grassroots level. The objective of this study was to characterize head kinematics experienced during open-wheel dirt track racing.

Methods

Four drivers were instrumented with mouthpiece sensors that recorded linear acceleration and rotational velocity at 200 Hz. Data was collected at dirt track races across the United States in 2021. Collected data was paired with time-synchronized film and reviewed via a custom MATLAB application to extract signals associated with complete laps. For each lap, moving averages of head motion signals were computed and subtracted from the original signals to obtain 'adjusted' head motion irrespective of periodic motion around the track. From adjusted data, linear and angular perturbations (i.e., deviations from moving average) were extracted using a custom MATLAB algorithm. Peak resultant kinematics (i.e., linear acceleration [PLA], rotational velocity [PRV], and rotational acceleration [PRA]) of each lap were reported as well as the frequencies and magnitudes of perturbations experienced within laps.

Results

Data were collected from 521 driver-races (primarily midget car events). A total of 2595 laps were segmented. PLA of laps ranged from 1.22 g to 26.8 g with a median (95th percentile) of 5.36 (8.26) g; PRV ranged from 0.76 rad/s to 19.0 rad/s with a median (95th percentile) of 2.89 (4.62) rad/s; and PRA ranged from 71.1 rad/s^2 to 3050 rad/s^2 with a median (95th percentile) of 179 (309) rad/s^2 (Figure 1). The frequency of linear perturbations per lap ranged from 3.07 Hz to 25.0 Hz (median = 6.48 Hz), while the frequency of angular perturbations ranged from 3.05 Hz to 25.0 Hz (median = 5.34 Hz). Linear perturbations had a median (95th percentile) PLA, PRV, and PRV of 1.78 (3.66) g, 0.80 (1.85) rad/s, and 61.2 (126) rad/s^2, respectively; angular perturbations had median (95th percentile) values of 1.71 (3.52) g, 1.05 (2.09) rad/s, and 65.7 (131.0) rad/s^2, respectively.

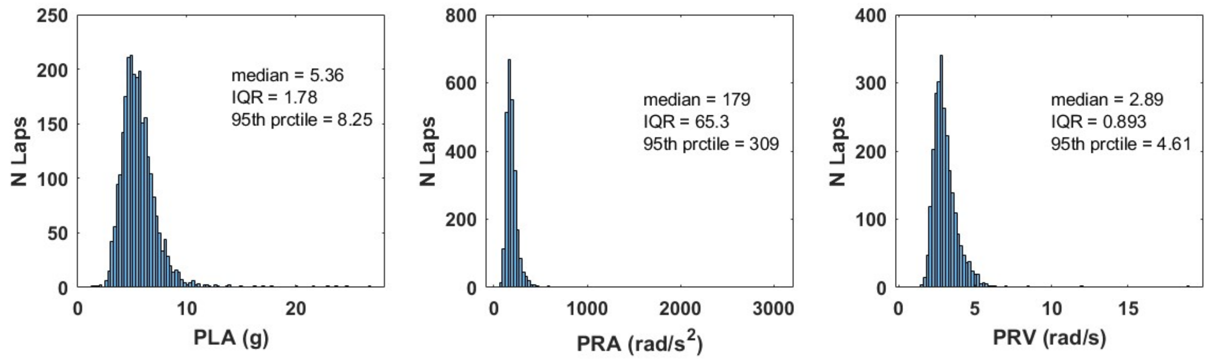

Figure 1. Distributions of PLA, PRA, and PRV during racing laps.

Discussion

Mouthpiece sensors were used to measure driver head motion during open-wheel dirt track races. Results represent the first attempts to characterize head motion experienced in this environment. For context, the average peak kinematics of high school football impacts recorded by the mouthpiece sensors were 19.2 g, 10.2 rad/s, and 980 rad/s^2. Future work will characterize exposure differences between drivers, tracks, and vehicle classes. Analyses may inform interventions to improve driver safety in auto racing.