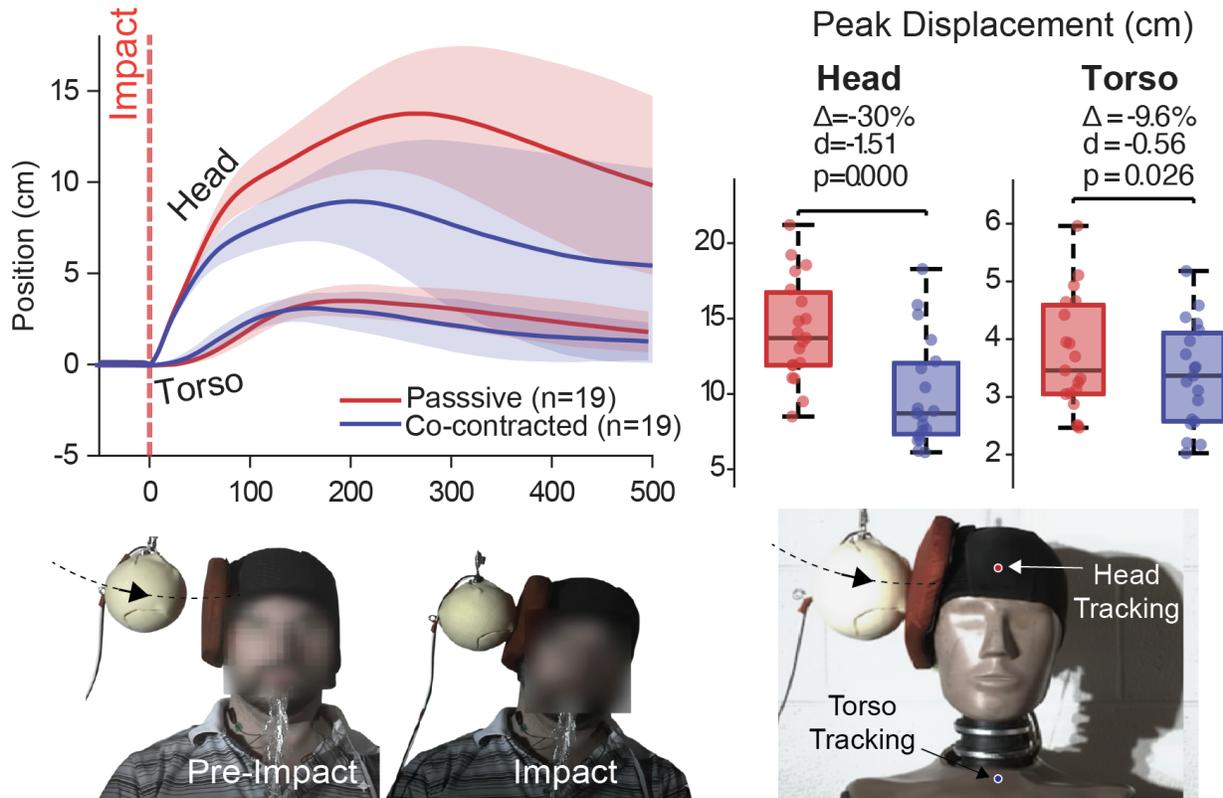


Abstract

Video analysis of human lateral head impacts reveals muscle co-contraction reduces head excursion relative to torso

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Introduction: Anthropomorphic test devices (ATDs) and human body models require empirical head and torso kinematic data to better predict injury risk. Reynier et al. (2020) characterized head kinematics during non-injurious lateral impacts under different muscle activation conditions, but their analysis focused exclusively on head motion. We performed secondary analysis of their high-speed video data to quantify simultaneous head and torso kinematics for ATD biofidelity assessment.

Methods:

We digitized high-speed video recordings from 19 male participants who received standardized lateral head impacts under passive and co-contracted muscle conditions. A 3.7 kg padded impactor struck participants at 2 m/s while cameras captured motion at 500 Hz. We tracked head and torso positions from video and computed velocity and acceleration metrics. We detected impact onset using a velocity threshold and compared conditions using paired t-tests with effect sizes.

Results: Muscle co-contraction reduced peak head displacement by 30% (passive: 14.2 ± 3.4 cm; co-contracted: 10.0 ± 3.6 cm; $p < 0.001$, $d = 1.51$). Peak head velocity decreased by 6.4% ($p = 0.003$, $d = 0.78$).

Torso velocity and acceleration showed no significant differences between conditions ($p > 0.05$). Head excursion relative to torso decreased 36% with co-contraction (passive: 11.3 ± 3.3 cm; co-contracted: 7.2 ± 3.2 cm; $p < 0.001$, $d = 1.35$). Individual displacement responses demonstrated consistent proportional reductions across conditions (slope = 0.70, $R^2 = 0.46$).

Discussion:

While peak acceleration remained unchanged, muscle co-contraction reduced head displacement and excursion relative to the torso following lateral impact. Our video-based approach captured displacement trajectories that can be tricky to capture using accelerometer-only methods. The time-series data and head excursion metrics address a need for developing more biofidelic ATDs used in automotive safety and sports injury research. The consistent proportional reduction in head displacement across participants supports development of scalable muscle activation factors.