Introduction

- Cycling is the leading cause of sport-related head injuries in the US.¹
- Bicycle helmets must comply with standards limiting peak linear acceleration (PLA) to 3,000 g in impact testing.
- Limitations of standards:
  o Pass-fail: do not provide data on which helmet designs offer better protection.
  o Test more severe impacts than those seen in typical cyclist accidents (~100 g).²
  o No testing at helmet rim, a common real-world impact location.³,⁴
- Only measure PLA in simplified normal impacts, while real-world accidents are oblique and involve rotational acceleration, a major contributor to concussion.⁴

Objective: To investigate differences in protective capabilities of bicycle helmets under real-world conditions using standard normal and oblique impact rigs.

Methods

- Normal (standard) impacts
- Oblique impacts

Impact Configurations

Low: average cyclist head impact
High: standard-specified for normal impacts, moderate for oblique impacts

Data Analysis

- Normal impacts: PLA
- Oblique impacts: PLA and peak rotational acceleration (PRA), concussion risk
- ANOVA, nonparametric correlations

Results

- PLA in normal impacts averaged 105 ± 22 and 227 ± 46 g at the low and high velocities.
- Temporal PLAs were higher, although two helmets bottomed out in the frontal-high velocity configuration and would have failed current standards.
- Many significant differences were found between helmet models.

Discussion

- Many significant differences in accelerations were found between helmet models. Oblique impacts showed considerable risk of concussion for some models.
- Temporal PLAs were generally higher than frontal PLAs, likely due to a larger radius of curvature at the temporal location, which produces larger contact areas and increases effective linear stillness.
- There were several PLA outliers in the frontal-high velocity configuration for both impact types. This location is not included in standards testing, but is a common impact location in cyclist accidents.²,³
- Non-road helmets were generally ranked lower, suggesting this style may offer inferior protection compared to road helmets.
- While helmet rank was similar across configuration and test rig, several helmets produced significantly greater PRAs and higher concussion risks, enhancing discrimination of overall performance.

Conclusions

- Significant differences exist in helmet performance under real-world conditions.
- Extreme PLAs were observed at the frontal location in the high-velocity condition, suggesting that standards testing should be expanded to include the helmet rim.
- There is clinical value in assessing helmet performance under oblique impacts, as these impacts reflect real-world accidents and enhance rank discrimination through the addition of rotational acceleration.
- These results can be used to inform standards testing and improve bicycle helmet safety.

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References:
1. IAANS. "Sports-related Head Injury." 2014

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