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Development of Standard Criteria to Evaluate the Effectiveness of Helmets at Decreasing the Risk of Concussions

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ABSTRACT

In many sports, such as American football, accumulations of mild traumatic brain injuries have been suggested as a possible link to neurodegeneration and future mental disorders. With head impacts occurring at all levels of competition and in different sports, it is critical to develop an accurate method for quantifying the effects of head impacts and determining the efficacy of helmets. This study examines the derivation of different dimensionless numbers and ascertains the critical factors needed to predict the effects of head impacts, specifically the resulting accelerations from an impact. Given a known force of impact, parameters such as peak translation acceleration and impact duration were collected for a total of 200 impacts at 10 locations around the head. These parameters were used in conjunction with dimensionless numbers to compare various helmet designs across sports. Five input and four output criteria, or π variables, were derived using fundamental variables of total mass, width of neck, and the difference between muscle reaction time and the impact duration. By determining the coefficients of the governing equations for each output π variable, the impulse of impacts had a consistent effect on helmet efficacy, while the masses and radii of helmets contained confounding variables that made it difficult to predict the effectiveness of attenuating the head accelerations.

KEYWORDS

Helmet, dimensional analysis, concussion, biomechanics