

ASSESSING THE INTERCHANGEABILITY OF DIFFERENT IMPACT DEVICES TO REPLICATE A FOOTBALL HELMET TESTING PROTOCOL

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ABSTRACT

There are different helmet testing protocols that use different types of impact equipment. The purpose of this study was to demonstrate the efficacy of replicating a single protocol across standardized equipment. A National Operating Committee on Standards for Athletic Equipment (NOCSAE) headform was used with a Hybrid III neck on a linear sliding table for a series of impact tests on both a pendulum and a pneumatic ram. Impactor face and impactor mass were matched between systems. Three football helmets were evaluated using the Varsity Football STAR Methodology on both systems. The target velocities on the pneumatic ram were set to match the specified pendulum velocities of 3.1 m/s, 4.8 m/s, and 6.4 m/s. A total of 24 tests per helmet and system were conducted, consisting of four locations (front, front boss, side, back), three energy levels, and two trials at each test configuration. STAR values were computed to characterize overall helmet performance. The average percent difference in peak resultant linear and angular accelerations between the pendulum and the pneumatic ram were 1.6% ± 4.7% and 0.2% ± 5.9%, respectively. Average difference between STAR values from both systems was 0.143. These results are consistent with the variance observed within individual helmet models and demonstrate the efficacy of replicating different helmet impact protocols on a single impact system.

Keywords: biomechanics, linear, rotational, acceleration, concussion

INTRODUCTION

Football was reported to have the greatest number of recorded concussions out of 15 collegiate sports, according to the National Collegiate Athletic Association's Injury Surveillance System [1]. Symptoms of a concussion are typically evident at the time of injury, and research suggests that repetitive concussions could have lasting effects on the brain, including chronic traumatic encephalopathy (CTE) [2]. The instrumentation of football players has provided good estimates of the linear and angular head accelerations associated with concussive impacts [3]. Helmet design is one strategy to reduce risk of concussion on the field, specifically by designing helmets to minimize the linear and angular accelerations resulting from impact [4, 5].

Football helmets are tested to evaluate their performance in a number of different ways. The National Operating Committee on Standards for Athletic Equipment (NOCSAE) created a set of football helmet standards first published in 1973. These standards used a drop tower for helmet testing and an instrumented headform [6]. The initial testing protocol evaluated only linear accelerations, but has been very effective in mitigating catastrophic head injury in football players. It is suggested that both linear and angular accelerations are involved in causing a concussion [7]. This has led to the development of more advanced testing methods that use drop towers, pendulums, and pneumatic rams to evaluate linear and angular acceleration during helmet testing [6, 8]. In this study, we address the question of whether a single piece of equipment can be used to replicate different impact protocols.