

VALIDATION OF A HELMET SHELL-AND-LINER FINITE ELEMENT MODEL IN DYNAMIC FRONTAL AND LATERAL IMPACTS

Dale Johnson[12], Will Decker[12], F. Scott Gayzik[12]
[1]Wake Forest University School of Medicine
[2]Virginia Tech–Wake Forest University School of Biomedical Engineering and Sciences

ABSTRACT

Given the growing interest in mitigating concussion in contact sports, clinicians and engineers are turning to novel tools to study the effect of head impacts. The ultimate goal of this work is to develop a computational finite element (FE) model of an American football helmet. The helmet model, and others like it, are tools that may lead to improved protection of athletes, through better characterization of the complex mechanics at work during impacts. In this study, a FE model of a commercially-available Schutt Air XP Pro helmet was validated against previously-published experimental test data of frontal and lateral impacts at contact-sport relevant velocities (3, 4.5, and 6 m/s). Simulations occurred at the sub-assembly level and did not include the facemask or donned headform (shell and padding only). The structural response of the helmet shell and lining material was evaluated based on peak force and deflection data. The focus on structural response provides greater understanding of the energy transfer that occurs at the helmet shell and liner level itself. The model presents close agreement to experimental results with an average standard error of 11.5% across the full force and deflection range, and exhibited yet closer agreement over the range typically observed when donned on a test headform. This study provides an additional validation data point of a previously released and open source FE model of the Schutt Air XP pro helmet. Through model validation at sub-assembly levels, greater confidence at the full structure level can be achieved. The FEA model presented can be coupled with human body FE models in the future to study the mechanical etiology of concussion. Furthermore, the sub-component validation method can also be applied to model development of various forms of protective equipment.

Keywords: football, helmet, finite element model, structural response, sub-assembly validation

INTRODUCTION

There are approximately 300,000 incidents of sports related mild traumatic brain injury that occur each year [1]. These injuries occur at nearly every level of competition and across all age groups. In a study of concussion in high school athletes, 73% of concussions resulted from American football while 79% of athletes without diagnosis of concussion did not play contact sports [2]. Of reported concussions, high school American football players account for 60% [1]. Collegiate and National Football League (NFL) athletes exhibit head injury incident rates of 4.8% to 6.3% [3, 4] and 7.7% [5], respectively. Given the high incidence of concussion in football, there is clear motivation for the development of novel engineering approaches to improve protective equipment in football [6, 7, 8]. Among these tools are FE models, which can be used to represent the protective equipment worn by players. These advances have the potential for a broader impact in all contact-sports. FE models of helmets are well represented in the literature, including other applications [9, 10, 11]. The NFL has pledged to support an Engineering Roadmap which lists the development of a FE helmet model and other protective equipment, as a top priority [12]. The Schutt Air XP Pro helmet was one specific model that was developed as part of this engineering roadmap. The model of this helmet has undergone a large amount of testing and validation, and this study was conducted to present an additional point of validation for previously published work of the open source model [6]. Here, the isolated helmet-shell sub-assembly following the removal of the facemask was validated in dynamic frontal and lateral impacts. The headform alone was validated against matched experimental tests with a donned headform. While the facemask itself serves to absorb and