DEVELOPMENT OF A PNT-FOOTBALL HELMET TO REDUCE NECK LOADS AND HEAD INJURY METRICS IN FOOTBALL

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INTRODUCTION
Spinal cord injuries (SCIs) in football are rare but catastrophic events. The SCI incidence rate in the United States for high school, college, and professional football has been estimated as 0.52, 1.55, and 14 per 100,000 participants, respectively [1]. These injuries are very significant given the enormous economic and societal costs and the vastly diminished quality of life of the injured person. The large majority of these SCIs are a result of tackling, particularly when the head is down, resulting in head-first impacts. These impacts can result in high compressive axial loads being transferred into the cervical spine and can lead to potential vertebral fracture and contusion, or other injury to the spinal cord. In order to address such injuries, our group is developing a helmet [2] to mitigate the potential for spinal and spinal cord injuries, as well as minimize head injury risk, in head-first impacts. In particular, a prototype designed and intended specifically for the football market has recently been developed and dubbed the PNT-Football.

METHODS
The PNT-Football helmet uses a standard commercially available football helmet outer shell with the PNT mechanism and inner shell integrated within the outer shell. The latest prototype incorporates an advanced carbon fibre inner shell (Figure 1).

Figure 1: PNT-Football prototype
Head-first impacts were carried out to examine head and neck injury metrics. These impacts were simulated using a biofidelic headform from a Hybrid III 50th male percentile anthropomorphic test device (ATD) and a biofidelic surrogate neck for head-first impact [3] attached to a custom-designed drop tower. The head was instrumented with nine uniaxial accelerometers (Model 7264C-2000, Endevco Corp.), while the neck was instrumented with a 6-axis load cell located at the lower neck (Model 4366J Denton ATD Inc.). Each drop was imaged with a Phantom V9 (Vision Research Inc.) high-speed camera at 1000 frames/second. The impact velocities were approximately 3.0 m/s (±0.1 m/s). In addition, drop tests simulating oblique impacts away from the top of the head were also carried out using an in-house vertical drop rail and ball arm-mounted head form to examine the ability of the helmet to reduce linear head accelerations, and thus potential for concussion.

RESULTS
Preliminary proof-of-principle tests have shown reductions in axial neck loads by as much as 29% (Figure 2) and reductions in resultant linear accelerations at the center-of-gravity of the head by 36%. Rotational accelerations were also reduced by approximately 64%. All tests were compared against a standard commercially-available football helmet, indicating the successful performance metrics of the PNT-Football compared to a state-of-the-art helmet.

DISCUSSION & CONCLUSIONS
We are encouraged by the effective reduction of both brain and cervical spine injury metrics in this initial proof-of-concept football helmet. We have measured more extensive reductions in head acceleration and neck loads in earlier prototypes [2] and we are now working to further improve these metrics in future PNT-Football prototypes.

REFERENCES