INTRODUCTION

Pediatric cervical spine injuries account for roughly 10% of all cervical spine injuries across all age groups.\(^1\) \(^3\)

Anatomical differences in children may account for this increased vulnerability of the cervical spine (c-spine).\(^1\) \(^4\)

The broad objective of this research is to quantify biomechanical responses of the c-spine in children 5–7 years old to aid and improve the biofidelity of pediatric human body models (HBM) and anthropomorphic test devices (ATD).

However, this task is not possible without the development of a custom fixture that allows the quantification of c-spine biomechanics.

This study is focused on the validation of a custom head fixture to quantify volunteer c-spine biomechanics.

MATERIALS & METHODS

A custom head fixture was designed and machined as an attachment to a Biodex Isokinetic Dynamometer to quantify c-spine strength and stiffness of pediatric volunteers in the anterior-posterior (AP) and lateral directions (Figure 1).

Phase I

Mechanical Validation

- Evaluated in “worst-case” scenarios with increased speed and increased range of motion.
- Artifact interference
- Load distribution
- Repeatability

If the head fixture showed repeatable and consistent behavior, the head fixture was deemed safe for next step of validation.

Phase II

Fixture Validation with an Adult Cohort

- Evaluation of self-selected snug and loose helmet fits. Subject efforts were assessed with surface electromyography (sEMG) on the sternocleidomastoid and upper trapezius muscles.
- Torque response for all helmet fits, with no effort.
- Torque response for all helmet fits, with maximum effort.

Measurement accuracy was determined by comparing measurement outputs within the adult subjects to available literature.\(^5\) \(^6\)

REFERENCES CITED


3. Kumaresan KV, Chhabra AS, et al. Pediatric cervical spine injuries account for roughly 10% of all cervical spine injuries across all age groups.\(^1\) \(^3\)


5. Acknowledgements The authors would like to acknowledge the National Science Foundation (NSF) Center for Child Injury Prevention Studies at the Children’s Hospital of Philadelphia (CChIPS) for sponsoring this project. Thank you to Michael McNally, the Jameson Crane Sports Medicine Research Institute, and the IB family for their invaluable help during this project.

DISCUSSION & CONCLUSIONS

- There were no patterns between peak torque generation and helmet fit.
  - AP direction: all maximum peak torques occurred in extension.
  - Lateral direction: maximum peak torques occurred more frequently towards the subjects’ right.
- Comparing measured peak torques to the literature, we found that our protocol results in comparable torque calculations of the atlantooccipital junction.\(^6\)
- Helmet fit does not affect subjects’ ability to engage with the equipment nor to produce maximum torque during the 30°/s portion of the protocol in both directions.
- The custom head fixture produces consistent and repeatable data outputs.
- Next steps include testing pediatric volunteers 5–7 years old, to better understand the unique characteristics of the pediatric c-spine.

ACKNOWLEDGEMENTS

The authors would like to acknowledge the National Science Foundation (NSF) Center for Child Injury Prevention Studies at the Children’s Hospital of Philadelphia (CChIPS) for sponsoring this project and its Industry Advisory Board (IAB) members for their support. Lab staff and volunteers. The equipment used in this study was funded by the NSF. The authors would like to thank the CChIPS Industry Advisory Board (IAB) for sponsoring this project. Thank you to Michael McNally, the Jameson Crane Sports Medicine Research Institute, and the IB family for their invaluable help during this project.