CSA GROUP RESEARCH

EXECUTIVE SUMMARY

INVESTIGATION OF REQUIREMENTS FOR A NEW TEST PROTOCOL FOR HOCKEY HELMETS TO MEASURE ROTATIONAL MOTION CAUSING CONCUSSION

CSA Group

SEPTEMBER 2017

AUTHOR

T. Blaine Hoshizaki, PhD
Neurotrauma Impact Science Laboratory
University of Ottawa
Ottawa, Ontario

PROJECT ADVISORY PANEL

Patrick J. Bishop, PhD
Cathryn Cortissoz, *CSA Group*
Hélène Vaillancourt, PhD, *CSA Group*

CSA GROUP RESEARCH

In order to encourage the use of consensus-based standards solutions to promote safety and encourage innovation, CSA Group supports and conducts research in areas that address new or emerging industries, as well as topics and issues that impact a broad base of current and potential stakeholders. The output of our research programs will support the development of future standards solutions, provide interim guidance to industries on the development and adoption of new technologies, and help to demonstrate our on-going commitment to building a better, safer, more sustainable world.

CSAGROUP.ORG

HAVE QUESTIONS?
JOIN THE CSA GROUP RESEARCH COMMUNITY

Log in for free to participate in discussions, ask your questions and share your comments on this research project. **Community.csagroup.org**

EXECUTIVE SUMMARY

Concussions in ice hockey are an important public health issue in Canada and efforts are needed to intervene on their occurrence. CSA Group already has in place a performance standard (CSA Z262.1 – Ice Hockey Helmets) to which all hockey helmets intended for use in hockey governed by Hockey Canada must be certified. This performance standard has been, and continues to be, very effective in reducing the risk of serious head injuries caused by direct blunt impact. Currently, helmets meeting this standard have limited effectiveness against concussion because concussions are caused by violent rotational motion of the skull and brain.

In an effort to develop a test protocol to help limit head rotation in ice hockey, CSA Group has sponsored a major research undertaking in which a range of head impacts associated with concussive injuries in the game were examined. These included impacts from falls to the ice, against the boards or glass, from opponents' elbows and from opponents' shoulders. The tests involved a standardized head model commonly used to study car crash safety (a Hybrid III head-form) mounted on a moveable neck model, and impacted using a monorail drop tower, a pneumatic (air) linear impactor, and a series of impact anvils (flat and angled) and strikers to simulate the appropriate impact condition. The head-form was fitted with a hockey helmet and an accelerometer array located near its center of mass that measured the effects of a blow. The helmeted head-form was subjected to impacts at different velocities and locations on the head to simulate the concussive events common in ice hockey. The acceleration signals (x, y, z axes and the resultant) were then used to determine the potential trauma to the brain by measuring Maximum Principal Strain (MPS) using two computerized Finite Element Brain Models (FEMs), the University College of Dublin Brain Trauma Model (UCDBTM) and the Wayne State University Brain Injury Model (WSUBIM). The dynamic response variables of linear acceleration, rotational acceleration, the change in linear velocity (Δv) and the change in rotational velocity ($\Delta \omega$) were determined and compared for their ability to predict brain strain (MPS). The test protocol results were also compared to reconstructed real life concussive injuries to elite ice hockey players.

The following observations, related to the development of a suitable test protocol, were found:

- Impact location on the head is important as some locations create more injury risk than others. Thus, to capture the variance associated with risk of injury it is important to test at multiple locations.
- In order to capture the risk posed under the injury conditions examined, an appropriate test protocol must include a range of impact velocities that are reflective of real life impact events in hockey.
- Accounting for the duration of the impact event is also important when considering injury risk.
- When all data was pooled together, all variables were shown to be significant predictors of brain strain (MPS).
- When separated into the different impact events, not all variables were able to effectively predict MPS.
- These results of this study highlight the need for examining helmet safety in terms of the impact characteristics of the events that create the risk for concussive brain injuries.

This research has provided valuable information for use in the development of suitable performance requirements for hockey helmets with respect to rotational motion of the head and brain.

About CSA Group

CSA Group is an independent, not-for-profit membership association dedicated to safety, social good and sustainability. CSA's strategic focus and core service offering includes: standards development; training solutions; consumer product evaluation; and global testing & certification. CSA products and services target a range of key businesses, including: hazardous location & industrial; plumbing & construction; medical safety & technology; appliances & gas; alternative energy; lighting; and sustainability. The CSA certification mark appears on billions of products worldwide. For more information about CSA Group visit **www.csagroup.org**.

CSA Group