Development and Validation of a Tool for Analysis of Hockey Related Head Impacts Captured on Video

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Learning Objectives

At the conclusion of this activity, the participant will be able to:

1. Gain insight into the development of this tool which can be reliably used to investigate the circumstances of head impacts occurring in ice hockey.

2. Gain an understanding of the preliminary results found from applying this tool, and of the implications for prevention of concussions at professional and amateur levels in ice hockey.
Ice Hockey & Concussion

- Highest concussion incidence in sport
- 6.5 concussions per 1000 player game hours on average (Koh et al., 2003; Ruhe et al., 2014; Tommasone et al., 2006)
- High risk for persistent symptoms (McCroy et al., 2008)
- Mechanism of concussion is often not accurately detailed
Existing approaches to evaluating head impact in hockey from video footage

<table>
<thead>
<tr>
<th>Tool</th>
<th>Purpose</th>
<th>Events analyzed</th>
<th>Main findings</th>
</tr>
</thead>
</table>
| The Heads-Up Checklist (Hutchison et al., 2014)                      | Concussive event, game situation and game sheet                         | -199 concussive events
-3.5 seasons of NHL level hockey | Majority of concussive hits initiated with opposing player’s upper limb |
| The Carolina Hockey Evaluation of Children’s Checking (Mihalik et al., 2010) | Player’s body positioning and anticipation of the hit                  | -666 body collisions
-one season of bantam level hockey | Anticipated hits resulted in less severe head impacts                  |
The IPML Head Impact Tool (I-HIT)

- 44 questions analyzing the biomechanical, situational, and environmental aspects of head impacts
- 32 questions analyzed independently by two research assistants
  - Trained using the I-HIT Instruction Manual
- For each response, raters described confidence level between 0-100% in “answer being correct”
<table>
<thead>
<tr>
<th>Part 1: Point of force application and dynamics of head contact (12 items)</th>
<th>Primary/ secondary/ tertiary point of contact [H], object contacting head [H], Aspect of head impacted [H], <strong>Level of head impacted</strong>, <strong>Head orientation wrt shoulders</strong>, <strong>Head orientation wrt ice</strong>, Acceleration left/ right [H], <strong>Acceleration up/down</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td>Part 2: Anticipation of collision (8 items)</td>
<td>Looking towards impending collision [H] [M], Knee flexion [M], Trunk flexion [M], Feet position [M], Shoulder driving [M], Leg driving [M], <strong>Nature of anticipatory strategy</strong></td>
</tr>
<tr>
<td>Part 3: Player positions and velocities at impact (4 items)</td>
<td><strong>Trajectory of players</strong>, <strong>Speed of player receiving check</strong>, <strong>Speed of player delivering check</strong>, Skates off ice</td>
</tr>
<tr>
<td>Part 4: Role of the arm of the hitter (6 items)</td>
<td><strong>Role of shoulder</strong>, <strong>Role of elbow</strong> [M], <strong>Upper limb initial contact point</strong>, <strong>Upper limb final contact point</strong>, <strong>Upper limb direction of movement</strong>, <strong>Upper limb trajectory</strong></td>
</tr>
<tr>
<td>Part 5: Game situation (2 items)</td>
<td>Playing zone [H], Puck possession [H] [M]</td>
</tr>
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Methods

- 30 videos of head impacts in the NHL, randomly selected from YouTube (n=12) and from the NHL Department of Player Safety’s website (n=18)

- 2011-2012 through 2014-2015 seasons
Statistical Analysis

- Total Percent Agreement (TPA)
- Cohen’s Kappa
- Prevalence and Bias Adjusted Kappa (PABAK)
  - Used for questions (n=9) that produced a 2x2 contingency table

<table>
<thead>
<tr>
<th>Range of Kappa Values</th>
<th>Strength of Agreement</th>
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</thead>
<tbody>
<tr>
<td>0.00-0.20</td>
<td>Slight</td>
</tr>
<tr>
<td>0.21-0.40</td>
<td>Fair</td>
</tr>
<tr>
<td>0.41-0.60</td>
<td>Moderate</td>
</tr>
<tr>
<td>0.61-0.80</td>
<td>Substantial</td>
</tr>
<tr>
<td>0.81-1.00</td>
<td>Almost Perfect</td>
</tr>
</tbody>
</table>

(Landis & Koch, 1977)
Inter-Rater Reliability Results

• All 32 questions had a TPA greater than 70%
  • mean = 85%
  • SD = 10%
• 30 questions had a Kappa value greater than 0.40
  • mean = 0.71
  • SD = 0.15
• Confidence ranged from 81 – 98%
Part 1: Point of force application and dynamics of head contact

- What body part or object initially collided with the player’s head?
  - TPA = 87%, K = 0.84
  - 30% shoulder, 20% glass, 13% elbow, 13% hands
Part 2: Anticipation of Collision

- Did the player alter their body position significantly in an attempt to lessen the impact of the impending collision?

- TPA = 83%, K = 0.67
  - 70% no attempt to lessen impact
Part 3: Player positions and velocities at impact

- What was the relative trajectory of movement between the two players at the time of initial impact (in reference to the shoulders of the player being hit)?
  - TPA = 77%, K = 0.67
  - 43% directly from the front, 30% angle from the front
Part 4: Role of the Arm of the Hitter

• In what direction did the upper limb move while delivering the contact force to the head?
  ▫ TPA = 87%, K = 0.82
  ▫ 33% away from the lateral side of the body

• What was the trajectory of the delivered contact force from the upper limb?
  ▫ TPA = 77%, K = 0.65
  ▫ 40% straight towards the opponent’s head
Part 5: Game Situation

- Did the player receiving the hit have possession of the puck at the time of the hit?
  - TPA = 80%, K = 0.72
  - 37% just released the puck, 23% attempting to gain possession of the puck
Conclusions

• The I-HIT reliably assesses the biomechanical, situational and environmental aspects of head impacts in ice hockey by combining important elements from published tools and introducing novel elements:
  ▫ direction of contact force to head
  ▫ orientation of player’s head prior to impact
  ▫ relative player positions and velocities
  ▫ anticipatory strategies
Limitations

- Focused on body checks involving head impact between professional NHL players
- 60% resulted in supplementary discipline
- Quality of videos varied
- Described trends in nature of impacts based on a small sample (n=30)
Ongoing Work

- Collection of head impact data in partnership with SFU Men’s Ice Hockey Team
  - Video footage of home games
  - In-helmet sensor data
- Design and evaluation of shoulder pads, compliant glass and boards
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Obtaining CME/CE Credit

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References


