ASSOCIATION BETWEEN CONCUSSION UNDERSTANDING AND STAKEHOLDER KNOWLEDGE
TRANSLATION IN COLLEGIATE SPORTS

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Abstract

The purpose of this study was to determine if there was an association between concussion understanding and stakeholder knowledge translation in collegiate sports following the mandate of Rowan’s Law in July 2019. To our knowledge, this is the first study to examine concussion knowledge translation within a sport network using social network analysis. A cross-sectional design was used to evaluate 76 collegiate athletes (54 females, 21 males, 1 not identified), aged 20.55 years (SD=3.4) who completed a survey on sport demographics, concussion knowledge and stakeholders who provided concussion information during the sport season. Athlete concussion knowledge scores and reported stakeholders were examined. An average of 3 key stakeholders provided concussion information to 82% of the varsity athletes in our study. Athletes reported that a coach or athletic trainer most often provided concussion knowledge. Overall, athlete concussion knowledge scores were the same for athletes who sought concussion knowledge from stakeholders and those who did not. Over 95% of athletes in the study did not access the Rowan’s Law website for mandated concussion education. These findings suggest that Rowan’s Law is hugely neglected resulting in stakeholder knowledge translation having minimal influence on an athletes’ understanding of concussions. Future recommendations include verified review of mandated concussion education resources and testing of concussion knowledge for all persons associated with sport in Ontario. Due to the large number of athletes seeking concussion knowledge in their varsity athlete network, accurate sport specific resources should be provided to support stakeholders who are in direct contact with athletes.
Acknowledgements

“When one door closes, another opens; but we often look so long and so regretfully upon the closed door that we do not see the one which has opened for us” - Alexander Graham Bell

My research on concussions has been an ongoing journey that has pushed me academically and personally, to depths I never knew existed. First and foremost, I would like to thank my supervisors, Dr. Brent Faught and Dr. Martha Barnes. Their commitment, support and mentorship throughout this research has provided me with the knowledge and confidence to complete my research and attain my goals. Thank you for believing in me and my research, your patience and expertise allowed me to see through my personal connections and concentrate on broader research applications. I would also like to thank my committee member Dr. Madelyn Law, your knowledge and experience allowed me to use a different lens when exploring policy, athletes and concussions.

I would also like to thank Brock Sports, especially Dr. Anna Lathrop, your ongoing support to set quality standards for your athletes is remarkable. Your care and compassion for Brock athletes is shown through your commitment to strengthen knowledge translation at every level for each athlete. To my participants, without your honesty and participation this research would not be possible.

Lastly, I would like to express my sincere gratitude to my family. Each of my children have supported and applauded each milestone with me, from my undergraduate degree to my final thesis, my journey would not have been possible without each of you.

A very special thank you to Daniel, when you were hurt, I set aside everything else and returned to school, I hoped that my research would make a difference one day. You inspired me to overcome any difficulty and look for the ‘open doors’ and keep going.
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Definition of Terms

Concussion: Trauma to the brain resulting from a blow exerted on the body, which can briefly affect the brain’s neurological functions (McCrory, et al., 2009).

Concussion understanding: Information, facts and skills to properly identify and manage suspected head injuries from onset of occurrence.

Varsity athlete: A student athlete who participates in sport competition organized by their academic institution. Each athlete represents their university at matches, games or tournaments that are held provincially and nationally.

Knowledge Translation: A dynamic and iterative process that includes the synthesis, dissemination, exchange and ethically sound application of knowledge to improve health, provide more effective health services and products, and strengthen the health care system (Straus, et al., 2009, p. 165).

Knowledge translation stakeholder: A source of concussion information for varsity athletes.

Second-impact Syndrome: the syndrome occurs when an athlete who sustains a head injury, often a concussion or worse injury, such as a cerebral contusion sustains a second head injury before symptoms associated with the first have cleared (Cantu, p. 38).
1.1 Preamble

Studies found that poor concussion knowledge and understanding contributed to nonreporting and continued sport participation by athletes with a head injury (Register-Mihalik, Guskiewicz, McLeod, Linnan, & Mueller, 2013). Identification and reporting of concussion symptoms are important to properly manage suspected brain injuries. Athletes who continue competing with a concussion are at risk for increased harm (Tator, et al., 2019) and longer recovery times (Asken, et al., 2016). Researchers know that there is a gap in concussion knowledge transfer, while continued efforts to educate the public is a priority (McCrory, et al., 2013). When knowledge is transferred from researchers to stakeholders, gaps often occur separating research evidence, policy and practice (Hanson, et al., 2012). Knowledge translation seeks to address the gaps that occur when knowledge is transferred to key stakeholders for use in a real-world setting (Canadian Institute of Health Research, 2016).

Uptake of new information (i.e., policies, rules) can be difficult and may not be accepted or understood due to barriers such as social norms, attitude, and understanding associated with each individual or organization (Kroshus, et al., 2015). Uptake and use of new information can be influenced by interpersonal exchanges as relationships provide a framework for adoption of new behaviours, learning, attitudes, and decision making (Green, et al., 2009; Valente & Pitts, 2017). Information is often exchanged through connections that are made within a group or ‘network’ of people in an organization or community. Valente’s (2010) research suggests that individuals are influenced by their social network, resulting in behavioural changes and adoption of new practices that can affect personal outcomes. To better understand relations between individuals and groups within a social network, sociograms and mathematical models used in social network analysis can uncover relational patterns within networks (Freeman, 2008).
In Ontario, efforts to address sport concussion knowledge was enacted in July 2019 with the advent of Rowan’s Law, which mandated that all sport organizations provide concussion information to all persons associated with sport (Government of Ontario, 2019). To our understanding, no research has examined the flow of concussion knowledge within a sport network using social network analysis. The implementation of Rowan’s Law necessitates this level of understanding surrounding concussions in sport. Exploring patterns of concussion knowledge translation amongst all stakeholders within a network can provide insights as to how information is shared within a sport organization and whether successful knowledge translation occurs. Therefore, the impetus for the proposed research study was to evaluate level of concussion understanding and stakeholder knowledge translation within a collegiate sports organization.

1.2 Research question

Is there an association between concussion understanding and stakeholder knowledge translation in collegiate sports?
2.1 Knowledge translation

Efforts to disseminate research findings into action have been ongoing for decades within many fields of study (i.e. education, engineering, health), and various terms are used to identify this exchange (knowledge translation, research use, dissemination, knowledge uptake) (McKibbon, et al., 2010; Straus et al., 2011). Transfer and use of knowledge is critical in providing health services, which former Director General of World Health Organization, Lee Jong-wook, describes as; “Health work teaches us with great rigor that action without knowledge is wasted effort, and knowledge without action is a wasted resource” (World Health Organization, 2005, p. 1). Knowledge translation involves a dynamic exchange of information to ensure targeted stakeholders are aware of research evidence and use this knowledge to make informed decisions (Jones, et al., 2015).

Often, evidence gathered by researchers does not reach intended populations to improve health, creating gaps between research and implementation of knowledge (Graham, et al., 2018; Macleod, et al., 2014). Knowledge translation seeks to “fill the evidential gap between knowledge and practice; a process that is considered by the World Health Organization to be one of the most important public health challenges of this century” (Poot, et al., 2018, p. i3). The gap between knowledge and practice is also known as the Knowledge-to-Action (KTA) gap, where increased efforts to inform and educate targeted stakeholders (decision makers, administration) must take place to ensure information is further disseminated to broader populations (healthcare providers, clients and the public) (Graham, et al., 2006; Poot, et al., 2018).
2.2 Knowledge translation models

Models and frameworks provide foundational theories and guidelines for knowledge translation including; Knowledge-to-Action (Graham, et al., 2006), Promoting Action on Research Implementation in Health Services (Kitson, et al., 1998), and Knowledge Utilization (Lavis, et al., 2003). While differing in approaches, the overall goals are the same; effective distribution of knowledge from academics to targeted stakeholders for improvement of public health. The KTA framework (Figure 1.1) is the accepted model for knowledge translation by the Canadian Institutes of Health Research (Canadian Institute of Health Research, 2016).

Figure 1.1 The Knowledge-to-Action Process Framework (Graham, et al., 2006)
The KTA framework requires collaboration between researchers and end-users, whereby information is used in a dynamic, complex process (Straus, et al., 2009). The KTA framework uses both knowledge creation and an action process to promote translation of information from researchers to end-users.

The knowledge creation process is deliberate, focused on knowledge that is useful and ‘packaged’ (i.e. guidelines, user-friendly formats) for maximum uptake by potential recipients (Graham, et al., 2006). The second part of the KTA framework is a dynamic action process, wherein identification of stakeholder needs and adaptation of information is made to overcome potential challenges of the users (i.e. geographical location, demographics, social norms) (Graham, et al., 2006; Straus, et al., 2009). Monitoring and evaluation of knowledge use and sustainability is included in the action process to ensure uptake of information (Graham, et al., 2006; Provvidenza, et al., 2013).

Knowledge translation was successfully applied in developing countries to promote breastfeeding, resource and network connections were made within each local community to support uptake of information, resulting in behavioural change through education and adoption of knowledge (World Heath Organization, 2003). Successful knowledge transfer utilizing the KTA framework has increased health practices in; child immunizations, betterment of nursing care, and pain management in children (Bacsu & Macqueen Smith, 2011; Taddio, et al., 2013). Involvement and collaboration with targeted end-users in the aforementioned studies, reinforces the importance of involving stakeholders in the knowledge translation process to increase behavioral change needed for adoption of new knowledge (Graham, et al., 2006).

2.3 Knowledge translation stakeholders

Social relationships can influence individual health attitudes and adoption of knowledge, the individual (messenger) and the interpersonal context that information is delivered can be equal or more important
than the actual information (Valente & Fosados, 2006). Clear communication, networking and building of relationships can foster implementation of knowledge creating long-term change within populations (Dixon & Elliott, 2019). Knowledge translation undertaken collaboratively within social networks provides the context for optimal learning and sharing (i.e. personal experiences, situational strategies) (Stewart & Abidi, 2012). Understanding various connections within networks can provide key insights for translating health research to end-users (Glasgow & Emmons, 2007).

2.4 Concussion level of understanding

Sport related concussions (SRC) are defined as, “traumatic brain injury induced by biomechanical forces” (McCrory, et al., 2017, p. 839). Often, typical indicators of SRC can include; a blow to the head or body resulting in a force exerted on the brain, brief transient disturbances in neurological functioning immediately or hours after an injury has occurred. Concussions may cause clinical changes in all or one of the following domains; cognitive (‘feeling in a fog’), emotional (rapid mood changes), physical (loss of consciousness), social (changes in behaviour). The onset of symptoms can be immediate or delayed dependent on the injury and individual (McCrory, et al., 2017). Due to variations in symptoms, knowledge of concussions is essential for timely, accurate management of suspected head injuries to mitigate harm.

In Ontario, over 1,330,000 individuals were formally diagnosed with a concussion between 2008 and 2016 (Langer, et al., 2019). Research suggests over 50% of athletes who experience a concussion do not report the injury to an authority figure (Beidler, et al., 2018) leaving many players undiagnosed with an increased risk for Second-impact Syndrome, repeated concussions and long-term consequences (Cantu, 1998; Tator, 2013). Underreporting by athletes is caused by a lack of concussion awareness and implementation of knowledge (Cusimano, et al., 2017; McCrea, et al., 2004; Meehan III, et al., 2013).
Effective dissemination of information is important to reduce the gap in concussion knowledge (McCrory, et al., 2013).

2.5 Concussion knowledge translation

Concussion knowledge gaps differ due to factors associated with targeted populations (i.e. age, attitudes, location, and peer influence) (Mrazik, et al., 2015). Effective dissemination of concussion knowledge can also be affected by concussion history (Register-Mihalik, et al., 2017), avoiding removal from play, and misunderstanding the seriousness of concussions (McCrea, et al., 2004; Register-Mihalik, Linnan, Marshall, McLeod, Mueller, & Guskiewicz, 2013; Wallace, et al., 2017). Additionally, conformity to team norms (Kroshus, et al., 2015), not reporting head injuries and continuing play to ‘not let teammates down’ (Register-Mihalik, Linnan, Marshall, McLeod, Mueller, & Guskiewicz, 2013), contributes to gaps in concussion knowledge translation.

When targeted populations do not understand the importance or relevance of new information, limited learning occurs due to lack of motivation and or interest (Rogers E., 2003). Implementation of concussion knowledge from researchers to end-users is both a challenge and an important area for consideration when information is used to promote safe sport engagement and proper identification or management of injured individuals (Finch, et al., 2013). Evaluation of knowledge translation is important to increase concussion knowledge, understanding and awareness in sport (Provvidenza, et al., 2013). Analysis of knowledge translation within a sport network will provide information on the flow of concussion knowledge following the enactment of Rowan’s Law.

2.6 Summary

This review of literature summarized the importance of knowledge translation and accompanying challenges associated with dissemination of concussion information. Networks can provide effective...
pathways for dispersal of new information amongst members. Understanding how networks transfer concussion information can provide useful insights for knowledge translation strategies. Further, research exploring how concussion knowledge enters, flows through and is exchanged in a sport network using social network analysis has not been studied.
Chapter 3 - Methods

3.1 Study design and participants

Social network analysis focuses on relations among members, as a result SNA approaches often study whole populations with specific boundaries. In the current study the population was bounded by actors (athletes and the stakeholders) within a specific population (varsity network) and time (2019-2020 sport season) (Wasserman & Faust, 1994). A cross-sectional design was used to examine concussion knowledge translation within collegiate sport, all varsity and club athletes were invited to participate in the study. The inclusion criteria targeted varsity and club athlete membership. Nine hundred athletes were listed as potential participants. Ethics approval for human research was obtained from the Brock University Ethics Review Board (Appendix 1) and consent was assumed by participation in the online survey (Appendix 2).

3.2 Measures

Varsity athletes were emailed a link to an online questionnaire via QuailtricsXM. The online questionnaire included three areas of data collection, including subject descriptives, concussion level of knowledge and concussion knowledge translation.

3.2.1 Subject descriptive questionnaire

The subject descriptive questionnaire included information on age, sex, type of varsity sport played at the collegiate level, concussion history in varsity sports during and prior to the past athletic season. If an athlete was a member of more than one sport team, only the first response was recorded. For concussion history, if there was an occurrence, questions were asked if the concussion was reported and which stakeholder(s) were informed.
3.2.2 Concussion level of knowledge questionnaire

Participants completed a modified concussion knowledge questionnaire adopted from the Rosenbaum Concussion Knowledge and Attitudes Survey—Student Version (RoCKAS-ST) (Rosenbaum & Arnett, 2010). The Concussion Attitudes Index (CAI) from the original version of the RoCKAS-ST was not included in the current study as attitudes towards concussions were not investigated. Also, the concussion knowledge question about ‘freshman’ and corresponding year in college was not included as these terms are not frequently used within the study population. The modified questionnaire included 17 true/false questions on the symptoms, signs and resulting trauma of concussions and scenarios on return to play post concussion. A concussion recognition checklist with 16 symptoms included eight reported symptoms and eight distractor symptoms. A maximum cumulative score of 25 was possible for correct responses on the concussion level of knowledge questionnaire. The original RoCKAS-ST has previously established a test-retest reliably of 0.67 and an internal consistency range of 0.59-0.72 (Rosenbaum & Arnett, 2010). The RoCKAS-ST measure was re-evaluated with collegiate athletes and the Concussion Knowledge Index (CKI) reliability and validity was consistent with original data (Chapman, et al., 2018).

3.2.3 Concussion level of understanding

A sport-specific network was formed by asking each respondent to identify up to five individuals in their collegiate sports organization who had provided concussion knowledge in the past year of athletic competition. For each identified stakeholder, the relationship options from a drop-down menu included coach, teammate, athletic trainer, assistant coach, athletic director, academic faculty, friends, Brock health services, Brock sports webpage, family, Rowan’s Law website, external Brock sources and other. Participants were also asked to rate the perceived value of the concussion knowledge received for each identified individual using a Likert scale.
Data were also analyzed using social network analysis. Network data provided information on the operation of the whole network and the individual actors (members) with metrics including number of ties, density and eigenvector centrality. Ties are the relationships/affiliations between actors in the network, a high number of ties indicate actors who are well connected within a network and are often individuals who can rapidly diffuse knowledge (Provan, et al., 2004; Valente & Davis, 1999). An actor’s eigenvector centrality not only considers the number of ties associated with each member, but also who was tied. A high eigenvector centrality value suggests the actor is connected to other influential or well-connected members within the network (Hambrick, 2019). Density represents the “overall connectedness in a network” (Scott, 2017, p. 81) quantified by the ratio between occurring and potential relationships within the network. A higher density score indicates many relationships are established in the network (Hambrick, 2019).

3.3 Statistical analyses
Descriptive statistics conveyed subject information from the survey including age, sex, athlete history and reporting of concussions. Cumulative scores were calculated for the concussion level of knowledge questionnaire. Mann Whitney U tests assessed differences in concussion knowledge index scores for athletes with and without a previous concussion for five scoring sections, including knowledge, scenarios, symptoms, distractors, and cumulative overall score. Social network analysis measures for concussion knowledge from stakeholders were determined using UCINET 6 (Borgatti, Everett, & Freeman, 2002) and sociograms were developed to map social network analysis data using NetDraw (Borgatti, 2002). This analysis identified the relationships of stakeholders in key positions for concussion knowledge translation. Network analysis measures were calculated for 3 networks, including all athletes, athletes with concussion history and athletes with no concussion history. Sociograms were developed for each network. Kendall’s tau-b correlation assessed the strength of the relationship between
concussion knowledge scores and the number of stakeholders who provided concussion information and athlete concussion history. All analyses were conducted using SPSS, version 26 (IBM Corp, 2019). Level of significance was established at $\alpha \leq 0.05$. 
Chapter 4 – Results

4.1 Descriptive analysis of subgroups

Of the 142 responses, 76 participants (F= 54; M=21; not identified = 1) completed the Concussion Knowledge and Attitudes Survey used for analysis of athlete concussion understanding, the average age was 20.55+3.39 years. Of the 76 athletes with concussion knowledge data, 62 athletes provided stakeholder information allowing for further analysis of relationships within the varsity network. Table 4.1 provides description of sport and concussion history.

<table>
<thead>
<tr>
<th>Survey Question</th>
<th>Response</th>
<th>Athlete Concussion History in Specified Sport</th>
<th>Athlete History of Concussion (In any sport)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>2019 -2020 Prior to 2019 1 Concussion 2 or more</td>
<td></td>
</tr>
<tr>
<td><strong>Sport (self-identified)</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Baseball (n=3)</td>
<td>0</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td>Basketball (n=3)</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Cheerleading (n=6)</td>
<td>1</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>Curling (n=2)</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Dance (n=1)</td>
<td>1</td>
<td>1</td>
<td>0</td>
</tr>
<tr>
<td>Dragon Boat (n=1)</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Equestrian (n=5)</td>
<td>1</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>Fencing (n=4)</td>
<td>0</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>Figure Skating (n=2)</td>
<td>0</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>Golf (n=2)</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Hockey (n=5)</td>
<td>2</td>
<td>2</td>
<td>4</td>
</tr>
<tr>
<td>Lacrosse (n=3)</td>
<td>0</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>Sport performance (n=1)</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Ringette (n=4)</td>
<td>2</td>
<td>1</td>
<td>0</td>
</tr>
<tr>
<td>Rowing (n=5)</td>
<td>0</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td>Rugby (n=7)</td>
<td>2</td>
<td>2</td>
<td>0</td>
</tr>
<tr>
<td>Soccer (n=7)</td>
<td>0</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td>Softball (n=3)</td>
<td>0</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>Squash (n=2)</td>
<td>0</td>
<td>0</td>
<td>0</td>
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<tr>
<td>Swimming (n=1)</td>
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<td>Tennis (n=1)</td>
<td>0</td>
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<td>0</td>
</tr>
<tr>
<td>Track and Field (n=1)</td>
<td>0</td>
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</tr>
<tr>
<td>Volleyball (n=3)</td>
<td>1</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td>Ultimate Frisbee (n=1)</td>
<td>1</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td>Wrestling (n=3)</td>
<td>0</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td>Other sport</td>
<td>1</td>
<td>4</td>
<td>-</td>
</tr>
<tr>
<td><strong>Total (n=76)</strong></td>
<td>12</td>
<td>16</td>
<td>17</td>
</tr>
<tr>
<td><strong>Concussion Rate</strong></td>
<td>15.79%</td>
<td>21.00%</td>
<td>22.37%</td>
</tr>
</tbody>
</table>
Concussion Reported: 10 (83.33%) 13 (81.25%) - -
Concussion Confirmed By: Doctor 7 8 - -
Team Trainer 2 3 - -
Self Diagnose 1 2 - -

* Athlete indicated 2 sports were played with first team recorded to avoid double recording of participant answers.

4.2 Concussion knowledge scores

The adapted concussion questionnaire contained 25 questions designed to assess an athlete’s understanding of concussion knowledge. Three questions were unrelated to concussion knowledge including two validity questions and a distractor question (Appendix 4) (Rosenbaum & Arnett, 2010). To ensure validity, data was reviewed to confirm respondents correctly answered one of the two validity control questions. Of the athletes (n=76) who completed the concussion knowledge section of the questionnaire, no data was excluded due to a low validity score. Concussion knowledge index scores were calculated for correctly answered questions on concussion knowledge and scenarios, symptoms and signs with a possible score of 25, the distractor and validity questions were not included in the total CKI score. Higher scores indicated increased concussion knowledge. Athlete knowledge was scored in five sections, complete listing of sections and questions can be viewed in Appendix 5.

Overall athlete CKI scores were 20.61 (+ 1.5) including scores for concussion symptoms and signs (7.47 out of 8), distractors (6.75 out of 8), scenarios (2.68 out of 3) and concussion knowledge (10.48 out of 14). Due to the non-normal distribution of scores and concussion history, and unequal group sizes of concussion scores for athletes (concussion history=23; no concussion history=53) a Mann-Whitney U test was used to investigate if there were significant differences in concussion knowledge scores for athletes with and without a history of concussions. Concussion knowledge scores and concussion history are listed in Table 4.2. There were no statistically significant differences in the medians of the two groups of athletes for overall CKI scores (U=476.00, z=-1.541, p=0.123, r=-0.177), concussion knowledge (U=568.50, z=-0.480, p=0.631, r=-0.550), concussion scenarios (U=607.50, z=-0.028, p=0.977, r=-0.003),
Table 4.2 Median Concussion Knowledge Scores for Athletes with and Without a Concussion History

<table>
<thead>
<tr>
<th>CKI Sections /possible score</th>
<th>No Concussion History (n=53)</th>
<th>History of Concussion (n=23)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Median</td>
<td>Median</td>
<td></td>
</tr>
<tr>
<td>Concussion Knowledge /14</td>
<td>11.00</td>
<td>11.00</td>
</tr>
<tr>
<td>Concussion Scenarios /3</td>
<td>3.00</td>
<td>3.00</td>
</tr>
<tr>
<td>Concussion Symptoms /8</td>
<td>8.00</td>
<td>8.00</td>
</tr>
<tr>
<td>Concussion Distractors /8</td>
<td>7.00</td>
<td>7.00</td>
</tr>
<tr>
<td>Overall CKI scores/25</td>
<td>20.00</td>
<td>21.00</td>
</tr>
</tbody>
</table>

Concussion symptoms (U=542.00, z=-0.899, p=0.368, r=-0.103), concussion distractor symptoms, (U=606.50, z=-0.035, p=0.972, r=-0.004).

Finally, athletes who did not receive concussion information from stakeholder(s) (n=14) had an average CKI score of 20.71 and athletes who received information from stakeholders (n=62) had an CKI score of 20.58. There was no statistical difference in concussion knowledge understanding between the two groups (U=422.00, z=-0.164, p=0.870).

4.3 Social network analysis

Athletes (n=14) who did not who did not respond or indicate receiving concussion information from stakeholder(s) were not included in the social network analysis, the remaining participants (n=62) received concussion information from stakeholder(s). Information gathered for the social network analysis provided data for one-way relationships from athlete to stakeholder. This type of data was 2-mode data known as affiliations or bipartite, where the athletes form relations or ties with stakeholders who provide information (Borgatti, et al., 2018). For analysis of centrality measures, data was transformed to full square matrices to support analysis. Data were kept in the original matrices for the generation of sociograms using visually depicting affiliations.

Social network analysis identified key stakeholders and the number of ties between varsity athletes and key stakeholders who provided concussion information. Sociograms of relationships were plotted using nodes to represent the athletes (red) and the stakeholders providing concussion knowledge (blue) with lines to show the ties or affiliations among the network members.
4.3.1 Network analysis of all athletes

The network of all athletes (n=62) who sought concussion information from key stakeholders (n=12) had a density of 17.7% that suggested a possible relationship within the network. This suggested a strong indication that strengthening of network relations is needed. Stakeholders with the highest eigenvector score (1.0) was coach followed by athletic trainer (0.935). This suggested that these two stakeholders are centrally located within the network with ties to centrally located athletes while stakeholders who are on the periphery of the network have a lower quality and number of connections within the network (Figure 4.1).

Figure 4.1 Affiliations among varsity athletes and providers of concussion knowledge
4.3.2 Network analysis of athletes with concussion history

The sport network of athletes with a concussion history (n=22) and members providing concussion information (n=12) saw 10 key stakeholders and 47 ties. The network had a density of 17.4%, suggesting potential relationships utilized within the network requiring strengthening of relations within the network (Figure 4.2). The eigenvector centrality measure was highest for athletic trainer (1.0), indicating they were most centrally connected to athletes. Brock Sport Page and Rowan’s Law website were not key stakeholders providing concussion information within the network for athletes with a concussion history.

Figure 4.2 Affiliations among varsity athletes with a history of concussions and providers of concussion knowledge
4.3.3 Network of athletes with no concussion history

The sport network of athletes without a concussion history (n=40) and members providing concussion information (n=12) saw 12 key stakeholders and 86 ties. This network has a density of 17.9% whereby possible relationships are established, requiring a strengthening of relations (Figure 4.3). In the network of athletes without a concussion history, the stakeholder with the highest eigenvector centrality score was the coach (1.0), suggesting that this stakeholder was the most central in this network. Stakeholders on the outer edge of the network have limited connections with centrally located stakeholders and athletes within the network.

Figure 4.3 Affiliations among varsity athletes with no history of concussions and providers of concussion knowledge
4.3.4 Individual stakeholder measures

Stakeholder eigenvector scores and number of ties associated with each athlete network is shown in Table 4.3. The network for athletes with a concussion history indicated that athletic trainer had the highest eigenvector centrality score of 1.0 followed by Brock Health Services (0.727). These two stakeholders have the most connections to central athletes within the network. In the network of athletes without a concussion history, coach has the highest eigenvector centrality (1.0) followed by athletic trainer (0.649). For the whole network of all athletes, the stakeholders with the highest eigenvector centrality was the coach (1.0) followed by athletic trainer (0.935).

<table>
<thead>
<tr>
<th>Stakeholders (n=12)</th>
<th>Athletes with Concussion History (n=22)</th>
<th>Athletes with No Concussion History (n=40)</th>
<th>All Athletes (n=62)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Degree/Tie</td>
<td>Eigenvector</td>
<td>Degree/Tie</td>
</tr>
<tr>
<td>Athletic Trainer</td>
<td>13</td>
<td>1.000</td>
<td>18</td>
</tr>
<tr>
<td>Coach</td>
<td>7</td>
<td>0.638</td>
<td>23</td>
</tr>
<tr>
<td>Brock Health Services</td>
<td>10</td>
<td>0.727</td>
<td>3</td>
</tr>
<tr>
<td>Teammate</td>
<td>2</td>
<td>0.102</td>
<td>10</td>
</tr>
<tr>
<td>External</td>
<td>3</td>
<td>0.146</td>
<td>6</td>
</tr>
<tr>
<td>Family</td>
<td>3</td>
<td>0.293</td>
<td>4</td>
</tr>
<tr>
<td>Assistant</td>
<td>1</td>
<td>0.087</td>
<td>6</td>
</tr>
<tr>
<td>Coach</td>
<td>3</td>
<td>0.064</td>
<td>4</td>
</tr>
<tr>
<td>Academic Faculty</td>
<td>2</td>
<td>0.113</td>
<td>4</td>
</tr>
<tr>
<td>Athletic Director</td>
<td>2</td>
<td>0.110</td>
<td>2</td>
</tr>
<tr>
<td>Friend</td>
<td>0</td>
<td>0.000</td>
<td>3</td>
</tr>
<tr>
<td>Brock Sport Web Page</td>
<td>0</td>
<td>0.000</td>
<td>3</td>
</tr>
<tr>
<td>Rowans Law</td>
<td>0</td>
<td>0.000</td>
<td>3</td>
</tr>
</tbody>
</table>
4.4 Concussion knowledge translation correlation

The average CKI score for athletes (N=62) who received information from at least one stakeholder was 20.58 (±1.55) with an average of 3 (±1.5) stakeholders providing information. Due to non-normal distribution of scores, Kendall’s tau-b correlation was used to analyze the association between athlete CKI scores and the number of stakeholders who provided concussion information. Kendall’s tau-b correlation indicated a positive association between number of stakeholders providing information and overall CKI scores (τb =0.255, p=0.013), concussion knowledge (τb =0.206, p=0.049), and concussion scenarios (τb =0.295, p=0.010). Conversely, there was no association between number of stakeholders providing information and scores for concussion symptoms (τb =0.007, p=0.946) or concussion distractors (τb =0.039, p=0.709). Additionally, there was no association between overall CKI scores and athlete concussion history (τb=0.141, p=0.213).

Kendall’s tau-b correlation was used to analyze the two groups of athletes (concussion history and no concussion history). Results of Kendall’s tau-b correlation (Table 4.4) indicated a positive association between number of stakeholders providing information for athletes with no concussion history and overall CKI scores (τb=0.286, p=0.026) and concussion scenarios (τb=0.300, p=0.035).

<p>| Table 4.4 Correlation for Athlete CKI Scores, Concussion History and Number of Stakeholders |
|----------------------------------------|-----------------------------------|-----------------------------------|-----------------------------------|-----------------------------------|-----------------------------------|-----------------------------------|-----------------------------------|</p>
<table>
<thead>
<tr>
<th>Concussion History</th>
<th>Overall CKI score</th>
<th>Number of Stakeholders</th>
<th>Concussion Symptoms</th>
<th>Concussion Distractors</th>
<th>Concussion Knowledge</th>
<th>Concussion Scenarios</th>
</tr>
</thead>
<tbody>
<tr>
<td>No</td>
<td>Number of Stakeholders</td>
<td>Kendall’s tau-b (2-tailed)</td>
<td>0.286*</td>
<td>1.000</td>
<td>-0.021</td>
<td>0.142</td>
</tr>
<tr>
<td></td>
<td>N</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Yes</td>
<td>Number of Stakeholders</td>
<td>Kendall’s tau-b (2-tailed)</td>
<td>0.249</td>
<td>1.000</td>
<td>0.113</td>
<td>0.191</td>
</tr>
<tr>
<td></td>
<td>N</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

* Correlation is significant at the 0.05 level (2-tailed).
Athletes reported that information provided by stakeholders increased concussion understanding (83.9%), strongly agreed (37.1%), agreed (46.8%), neutral (14.5%) and strongly disagree (1.6%). Athletes without a concussion history indicated information provided by stakeholders increased concussion understanding (87.5%), strongly agreed (37.5%), agreed (50.0%) and neutral (12.5%). Athletes with a concussion history found the information provided by stakeholders increased concussion understanding (77.3%), strongly agreed (36.4%), agreed (40.9%), neutral (18.2%), and 4.5% strongly disagreed that the information provided did not increase understanding.
5.1 Discussion

The purpose of this study was to determine if there was an association between concussion understanding and stakeholder knowledge translation in collegiate sports. Following the mandate of Rowan’s Law in July 2019 (Government of Ontario, 2019), knowledge translation was studied to determine athlete level of concussion knowledge and how concussion information is exchanged within an intercollegiate athlete network. An average of three key stakeholders provided concussion information to 82% of the varsity athletes in our study. Results indicated concussion knowledge scores had a positive association with an increased number of stakeholders providing information. Despite this association, no difference in understanding of concussions existed among athletes regardless of whether they received concussion knowledge from stakeholders or not. This result is important as it suggests that concussion knowledge translation from stakeholders did not influence overall understanding of concussion among athletes. An equally important finding was that 18% of athletes reported no stakeholder interaction to procure concussion knowledge. Additionally, of the athletes who received stakeholder knowledge, only 3.9% of these athletes accessed the mandated concussion education resources from Rowan’s Law website. In all, 96.1% of the study subjects neglected to review mandatory concussion information prior to sport play. Currently, all athletes must review mandated concussion education resources prior to registration and play in all Ontario sport (Government of Ontario, 2019). These findings suggest that Rowan’s Law is hugely neglected resulting in stakeholder knowledge translation strategies appearing to have minimal influence on an athletes’ understanding of concussions.

Aside from athlete failure to review mandated concussion education resources, athlete concussion knowledge could be affected by various factors. Athlete concussion knowledge can be influenced by the quality of stakeholder knowledge translation, an athlete’s ability to retain knowledge
as well as their use and perception of concussion resources. Despite evidence of increased understanding of concussions and access to stakeholder knowledge translation, overall knowledge scores for all athletes were the same regardless of concussion history and receipt of stakeholder concussion knowledge. Conceivably, this could be due to athlete knowledge retention. When knowledge is received, retained information decreases over time. On average, studies found a 50% reduction in knowledge retention at 8-10 months (Weggemans, et al., 2017) and one year (Faught, et al., 2016) after initial baseline knowledge verification. Similar findings of decreased knowledge retention at 55 days were reported when medical students were exposed to short academic tutorials (Bell, et al., 2008). Knowledge retention of long-term concussion education has not been thoroughly studied (Caron, 2019). The majority of concussion research has focused on short-term education outcomes of less than three months. One-time concussion education interventions have been evaluated with pre and post presentation quizzes. Gains in concussion knowledge were short-term while long-term benefits were unclear (Caron, et al., 2015). Even though athletes sought knowledge from stakeholders, non-significant differences in concussion scores could be due to decreased knowledge retention over time.

Furthermore, Rowan’s Law requires annual review of mandated concussion education resources. Athlete retention of concussion information over an entire year can result in decreased concussion knowledge. Additionally, review of numerous concussion resources has been ongoing for many years as new definitions and prevention strategies are published (Malcolm, 2020). Over time, exposure to multiple concussion resources can result in lack of interest to review more information. Recent studies suggest that information fatigue could result in lowered concussion knowledge (Kroshus, et al., 2015b).

To promote greater knowledge retention over time, literature suggests frequent brief exposure to concussion information by all persons involved in sport (athletes, officials, stakeholders) (Kroshus & Chrisman, 2019). Similarly, Bell and colleagues (2008) suggest weekly reinforcement of learning to promote longer retention of knowledge. Kroshus and Chrisman (2019) propose brief pre-game huddles
to affirm concussion safety protocols with athletes, coaches and stakeholders from both teams. Pre-game concussion huddles would be similar to medical safety huddles; a strategy to improve efficiency and decrease negative outcomes through communication, affirmation of shared values, and strengthened relationships (Provost, et al., 2015).

Stakeholder concussion knowledge was not tested in the current study. Similar to athletes, stakeholder retention of concussion knowledge can be problematic. It is not known if our stakeholders attained mandated concussion resources. Recent studies indicate the majority of Ontario hockey coaches that were interviewed failed to review the new mandatory concussion education resources as required by Rowan’s Law. The majority of coaches felt they were already involved in concussion education or they briefly reviewed the information (St Amant, 2020). Furthermore, stakeholder knowledge could be inconsistent due to the large number of concussion resources available online. Review of the top ten concussion sites ranked by Google provided information that was not complete or accurate (Berg, et al., 2014). Additionally, many internet sites providing concussion information can include complex language and inconsistencies, which can impede use of information (Ahmed, et al., 2011; Bekker & Finch, 2016; Mrazik, et al., 2015). Inconsistencies in concussion resources can have a substantial impact on stakeholder knowledge and subsequent exchanges of information between athlete and stakeholder.

To increase concussion knowledge, effective knowledge translation strategies can benefit both the athlete and stakeholder (Provvidenza, et al., 2013). Customization of resources can support stakeholder knowledge. The KTA framework uses resource tools supportive of the targeted population for optimal knowledge exchange (Graham, et al., 2006). Provvidenza and colleagues (2013) modified the KTA framework to provide concussion knowledge to sport coaches (Appendix 6). A modified KTA framework identifies specific implementation interventions that benefit the coaching population such as concussion specific coaching case studies or coaching concussion manual.
Consideration of specific sport and organizational resources should be an area of focus to ensure optimal conditions for learning and use of accurate concussion knowledge by stakeholders.

An athlete’s individual perception and interpreted use of concussion information can also influence concussion knowledge. Often, an athlete’s first exposure to safe sport play is provided by family members. Parental knowledge and acceptance of concussion information can lead to misconceptions about head injuries (Boneau, et al., 2020; Kroshus, et al., 2017). Furthermore, families who prioritize sport participation can mitigate the seriousness of concussions due to fears of decreased sport play and achievement when symptoms are self-reported (Boneau, et al., 2020). Athletes report feeling parental pressure to play through injuries, often prioritizing participation over well-being (Boneau, et al., 2020; Kroshus, et al., 2015). Recent studies found that collegiate athletes are still influenced by parental concussion safety. Despite their age, first year collegiate athletes continue the practice of their parental beliefs on concussion safety during sport play (Fuller, et al., 2020). Dispelling long-held beliefs surrounding concussions can be difficult and short-term educational efforts may not change athlete knowledge (Kroshus, et al., 2015b). Possibly, athlete concussion knowledge scores could be affected by long-held beliefs. Review of accurate concussion education resources is important for this group of athletes who may not realize the full dangers of a head injury.

Rowan’s Law requires annual mandatory concussion education for all persons associated with sport. Similarly, to uphold the Zachary Lystead Concussion Law (Lystead Law) in the United States, the National Collegiate Athletic Association (NCAA) requires annual mandatory concussion education for all athletes (National Collegiate Athletic Association, 2014). Each NCAA sport organization is responsible for providing concussion education materials to stakeholders, but it need not be standardized concussion resources. Variations in content and delivery formats can affect the efficacy of knowledge transfer, resulting in a wide range of concussion resources used by various sport organizations (Harvey, 2013). Adherence to the Lystead Law has also been known to vary, whereby one third of athletic coaches do
not receive yearly concussion resources from their sport organization (Kroshus, Baugh, & Daneshvar, 2016).

The Lystead Law has been in place since 2009 and sport organizations are still struggling to implement effective knowledge translation to key stakeholders and athletes (Kroshus, et al., 2014). In the current study, over 80% of athletes received concussion information from varsity stakeholders such as coaches and athletic trainers. Callahan and colleagues (2021) report both the content and the delivery of concussion information is important in effectively influencing athlete help seeking and reporting of concussions. Often sport education programs lack direction for evaluation on dissemination and implementation efforts (Finch, 2011). Mandates associated with Rowan’s Law should monitor dissemination of concussion information to ensure knowledge is translated accurately for athlete understanding and retention. To regulate adherence to Rowan’s Law, annual standardized testing of stakeholder concussion understanding can ensure information provided to athletes is aligned with mandated concussion education resources. Assessment of stakeholder concussion knowledge and understanding is important due to the large number of athletes who seek information from key stakeholders.

In the current study, athletes most frequently sought knowledge within their varsity athlete network. Those with a concussion history sought knowledge from the university athletic trainer and health services, aligning with help seeking knowledge from medical professionals when an athlete is injured (McLeod, et al., 2013). Athletes without a concussion history sought information more frequently from their coach, exemplifying the coach-athlete relationship when the event was non-emergent (Milroy, et al., 2018). Similar results indicated student athletes preferred delivery of concussion education from a coach, athletic trainer or team physician (Kroshus & Baugh, 2016 ). Relationships often promote knowledge translation (Valente, 2010). The athlete-coach relationship can provide information on concussion knowledge, help seek promotion and report of suspected head
injuries (Milroy, et al., 2018). Coach endorsement of concussion guidelines and protocols will promote similar actions in athletes (McCradden & Cusimano, 2019). Furthermore, supportive collaboration and relationship building between key stakeholders such as athletic trainers and coaches can provide uniform messaging to athletes. Often, athletes view a coach as being responsible for successful game performance, while athletic trainers provide health and safety care. Presenting a united front between athletic trainer and coach with respect to athlete concussions and injury may reinforce the importance of concussion safety and effectively transfer this information to athletes (Lininger, et al., 2019).

The athlete network indicated a low density for potential relations amongst members. Increasing connections between athlete members is not necessary for provision of concussion information. Conversely, increasing relations among key stakeholders would create a consistent flow of information and resources. Additionally, optimization of athlete-stakeholder relations can lower the number of isolates within the athlete network. Reduction of isolates can decrease potential gaps in knowledge translation. Creation and maintenance of relations within networks can increase acquisition of resources including research and knowledge (Barnes, et al., 2007).

Athlete sport networks can be closed and centralized where key individuals provide information and advice within the sport environment, often viewed as a negative experience (Nixon, 1992). In the current study, increasing the number of key stakeholders providing information, risks misinformation and inconsistent concussion knowledge due to the vast number of available resources (Bekker & Finch, 2016). Providing centralized stakeholders with current concussion information specific to unique sport environments can promote effective knowledge translation to athletes (Providenza, et al., 2013).

In the current study, both coach and athletic trainer demonstrated the highest eigenvector measures for centrality. The centralized positions within the network provide opportunity for distribution of mandated concussion knowledge translated to collegiate athletes. Predetermining actors that are influential within a given network can provide valuable information for future knowledge
translation and specific stakeholders who are critical in knowledge dissemination (Glegg, et al., 2019). Strategies to enable open communication and education among central stakeholders such as coaches or athletic trainers can optimize concise distribution of standardized and consistent concussion knowledge to athletes from centralized sources (Mrazik, et al., 2015; Provvidenza, et al., 2013). Use of athlete networks can be advantageous when stakeholders provide frequent review of mandated concussion resources to their athletes.

5.2 Limitations

The following limitations require addressing for future research on concussion knowledge understanding and translation within an athlete network. Information was not gathered from stakeholders within the network on their relations with other stakeholders. Coach and athletic trainer have key roles in disseminating information to varsity athletes within the current study. Understanding connections between key stakeholders can provide future direction to enhance relations and network building among key stakeholders. When communication and educational strategies are approached jointly at the stakeholder level, this can further support athlete reporting as well as consistent and accurate understanding of concussion injuries (Lininger, et al., 2019). Additionally, collaboration at the stakeholder level is important for consistent distribution of knowledge to the athlete for optimal knowledge translation (Denis & Lehoux, 2009; Provvidenza, et al., 2013).

The original study design included completion of surveys during athlete year-end exit programs. Due to the COVID 19 restrictions, all in-person contact was prohibited and reliance on email invitation was the only viable option. The number of online responses were considered low. Future research considerations should consider in-person athlete contact with support from varsity sport staff and administration to maximize collegiate athlete response.
5.3 Future recommendations

Accountability must take place to ensure Ontario athletes attain an acceptable level of concussion knowledge and understanding. Future recommendations include verified review of mandated concussion education resources and testing of concussion knowledge for all persons associated with sport. Currently, Rowan’s Law requires all persons associated with sport to acknowledge they have reviewed concussion education resources prior to sport registration (Government of Ontario, 2019). Current acknowledgment of reading concussion education resources must go beyond an ‘honour pledge’ that information was reviewed. Often, athletes do not adhere to long-term sport education initiatives (Malcolm, 2020). Safeguards to confirm mandated review and knowledge retention of concussion education is essential for prolonged learning through mandatory assessment, dispelling of inaccurate held personal beliefs and inconsistent concussion information. Assessment of concussion knowledge should take place prior to sport participation with a standardized level of demonstrated understanding. All persons associated with sport (athletes, stakeholders, officials) should be tested on their concussion knowledge to ensure understanding of the reviewed information. A minimum test score of 90% on concussion knowledge would verify true understanding leading to sport participation.

Monitored pre-season testing should be considered to decease sharing of information or seeking answers from online sources. Knowledge testing will ensure current concussion education resources from the Rowan’s law website is not only reviewed but understood.

5.4 Conclusion

This study indicates that concussion knowledge translation within a varsity athlete network is dependent upon relationships with key stakeholders. Use of personal stakeholders in this study supports the KTA framework where knowledge exchange is dependent on trusted relationships between stakeholders and end-users of knowledge (Graham, et al., 2006). Reliance on interpersonal
communications for concussion knowledge translation within a varsity athlete network requires effective strategies. Mandatory concussion level of knowledge testing and verified accurate sport specific resources must be implemented to ensure dissemination and understanding of mandated concussion information. Further, to increase stakeholder knowledge, provision of concussion resources that are relevant for education and use within Ontario sport organizations should be considered. Currently, seeking concussion information from stakeholders is not a requirement in varsity athlete networks. Future efforts should identify isolates to decrease potential gaps in knowledge translation. When isolate numbers are higher, knowledge translation within a network can be problematic. Ensuring all members within a varsity network understand concussion knowledge can influence public health decision making, promoting effective prevention and management of concussions.
References


doi:10.1097/HTR.00000000000000503


Certificate of Ethics Clearance for Human Participant Research

DATE: March 31, 2020

PRINCIPAL INVESTIGATOR: BARNES-FAUGHT, Martha and Brent - Health Sciences

FILE: 19-251 - BARNES-FAUGHT

TYPE: Masters Thesis/Project

STUDENT: Deborah Giguere

SUPERVISOR: Martha Barnes; Brent Faught

TITLE: Concussion Knowledge Translation in Collegiate Sports

ETHICS CLEARANCE GRANTED

Type of Clearance: MODIFICATION

Expiry Date: 3/1/2021

The Brock University Social Sciences Research Ethics Board has reviewed the above named research proposal and considers the procedures, as described by the applicant, to conform to the University's ethical standards and the Tri-Council Policy Statement.

Modification:
- Changes to questionnaire content

The Tri-Council Policy Statement requires that ongoing research be monitored by, at a minimum, an annual report. Should your project extend beyond the expiry date, you are required to submit a Renewal form before 3/1/2021. Continued clearance is contingent on timely submission of reports.

To comply with the Tri-Council Policy Statement, you must also submit a final report upon completion of your project. All report forms can be found on the Office of Research Ethics web page at http://www.brocku.ca/research/policies-and-forms/research-forms.

In addition, throughout your research, you must report promptly to the REB:
  a) Changes increasing the risk to the participant(s) and/or affecting significantly the conduct of the study;
  b) All adverse and/or unanticipated experiences or events that may have real or potential unfavourable implications for participants;
  c) New information that may adversely affect the safety of the participants or the conduct of the study;
  d) Any changes in your source of funding or new funding to a previously unfunded project.

We wish you success with your research.

Approved:

Lynn Dempsey, Chair
Social Science Research Ethics Board

Robert Steinbauer, Chair
Social Science Research Ethics Board

Note: Brock University is accountable for the research carried out in its own jurisdiction or under its auspices and may refuse certain research even though the REB has found it ethically acceptable.

If research participants are in the care of a health facility, at a school, or other institution or community organization, it is the responsibility of the Principal Investigator to ensure that the ethical guidelines and clearance of those facilities or institutions are obtained and filed with the REB prior to the initiation of research at that site.
Appendix 2 - Informed Consent

Project Title: Concussion Knowledge Translation in Collegiate Sports

Principal Student Investigator:
Deborah Giguere, Masters Student
Applied Health Sciences
Brock University
dv83fp@brocku.ca

Faculty Supervisors:
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INVITATION
You are invited to participate in a study that involves research.

WHAT’S INVOLVED
As a participant, you will be asked to complete an on-line questionnaire which should take approximately 10 minutes of your time. The purpose of the following questions is to help us understand the way that concussion knowledge is exchanged within a collegiate sport network. The results of the network analysis will be in the form of “maps” and quantitative measures (e.g., numbers) of network structure. The principal student investigator (D. Giguere) will review your individual responses for the purpose of completing the analysis, but your individual results will not otherwise be shared in a way that identifies your responses.

In the questions below, you will be asked to identify the names of other individuals with whom you received knowledge about concussions.

This is an example of how the results will appear. Any names of individuals that you provide will assist in creating the map, but no names will appear on the map itself or in the results, except as pseudonyms (i.e. “A”, “B”. etc.) as stated and only where necessary.
POTENTIAL BENEFITS AND RISKS
There are no known or anticipated risks associated with participation in this study. There are no direct benefits anticipated to participants. The results of the study will contribute to the scientific community through enhanced understanding of how concussion knowledge is exchanged.

CONFIDENTIALITY
The information you provide will be kept confidential. Your name will not appear in any research or report resulting from this study. Data collected during this study will be stored securely in the office of the principal student investigator. Access to this data (housed on a password protected computer) will be restricted to the principal student investigator (D. Giguere) and faculty supervisors (M. Barnes and B. Faught) of this study. All data will be destroyed 30 days after analysis has occurred.

VOLUNTARY PARTICIPATION
Participation in this study is voluntary. If you wish, you may decline to answer any questions or participate in any component of the study. Further, you may decide to withdraw from this study at any time by closing the browser and may do so without any penalty.

PUBLICATION OF RESULTS
Results of this study may be published in the form of thesis/dissertation, professional journals and presented at conferences. An executive summary can be obtained through Deborah Giguere after August 2020 by request to dv83fp@brocku.ca.

CONTACT INFORMATION AND ETHICS CLEARANCE
If you have any questions about this study or require further information, please contact Deborah Giguere using the contact information provided above. This study has been reviewed and received ethics clearance through the Research Ethics Board at Brock University, file #19-251 - BARNES-FAUGHT. If you have any comments or concerns about your rights as a research participant, please contact the Research Ethics Office at (905) 688-5550 Ext. 3035, reb@brocku.ca. Thank you for your assistance in this project. Please keep a copy of this document, this file can download, saved and printed for your records.

CONSENT
I agree to participate in this study described above. I have made this decision based on the information provided. I have had the opportunity to receive any additional details I wanted about the study and understand that I may ask questions in the future. I understand that I may withdraw this consent at any time. I understand that by selecting "I agree", I am giving my consent.
Appendix 3 – Questionnaire

Part 1 – General Information
Q1 Name
__________________________________________

Q2 What is your gender?
☐ Male
☐ Female
☐ Other

Q3 How old are you?
__________________________________________

Q4 What Brock sports team are you a member of?
__________________________________________

Q5 Have you experienced a concussion while participating in Brock varsity or club sports from July 2019- April 2020?
Yes
No

Display This Question: Have you experienced a concussion while participating in Brock varsity or club sports from July 2019- April 2020? = Yes

Q6 What sport was this in?
__________________________________________

Display This Question: Have you experienced a concussion while participating in Brock varsity or club sports from July 2019- April 2020? = Yes

Q7 Did you report the concussion to anyone?
Yes
No

Display This Question: Did you report the concussion to anyone? = Yes

Q8 Who did you report the concussion to? (select all that apply)
☐ Sport team staff
☐ Family member
☐ Teammate
☐ School staff
☐ Health Professional
☐ Friend
☐ Other
Display This Question: Did you report the concussion to anyone? = Yes
Q9 Who confirmed that you had a concussion?
☐ Doctor
☐ Team trainer
☐ Coach
☐ Self-diagnose (I just knew that I had suffered a concussion)
☐ Other

Q10 Have you EVER experienced a concussion while participating in Brock varsity or club sports prior to July 2019?
Yes
No

Part 2: Exchange of Concussion Knowledge
Q15 Please complete the following questions regarding the exchange of concussion knowledge within Brock sports.

We would like to know which individuals you believe are most responsible for providing concussion knowledge. These individuals may be coaches, athletic directors, teammates, academic faculty instructors or someone else who have been especially helpful in providing concussion knowledge.

Please list up to five (5) key individuals (and their relationship), who has provided you with concussion knowledge during the past year. After each name, rate the quality (usefulness) of concussion knowledge each person provided by responding to the following statement: the concussion knowledge was useful (helpful).

select relationship from drop-down options  
- Coach
- Teammate
- Athletic Trainer
- Assistant Coach
- Athletic Director
- Friend
- Academic Faculty
- Brock Health Services
- Brock Sports Webpage
- Family
- Rowan's Law Website
- External to Brock
- Other

The concussion knowledge was useful (helpful). Select from the drop-down options
- Strongly Disagree
- Disagree
- Neutral
- Agree
- Strongly Agree

1. First and Last Name ____________________ ▼ Coach (1 ... Other (10) ▼ Strongly Disagree (1 ... Strongly Agree (5)
2. First and Last Name ____________________ ▼ Coach (1 ... Other (10) ▼ Strongly Disagree (1 ... Strongly Agree (5)
3. First and Last Name ____________________ ▼ Coach (1 ... Other (10) ▼ Strongly Disagree (1 ... Strongly Agree (5)
4. First and Last Name ____________________ ▼ Coach (1 ... Other (10) ▼ Strongly Disagree (1 ... Strongly Agree (5)
5. First and Last Name ____________________ ▼ Coach (1 ... Other (10) ▼ Strongly Disagree (1 ... Strongly Agree (5)
Q16 Did the information provided increase your understanding about concussions?

Strongly agree

Agree

Neutral

Disagree

Strongly disagree

**Part 3: Concussion Knowledge**

Q17 Please answer the following questions to the best of your knowledge. **DIRECTIONS:** Please read the following statements and select TRUE or FALSE for each question.

<table>
<thead>
<tr>
<th>Statement</th>
<th>TRUE (1)</th>
<th>FALSE (2)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. There is a possible risk of death if a second concussion occurs before the first one has healed.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2. Running everyday does little to improve cardiovascular health.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>3. People who have had one concussion are more likely to have another concussion.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>4. Cleats help athletes’ feet grip the playing surface.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>5. In order to be diagnosed with a concussion, you must be knocked out.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>6. A concussion can only occur if there is a direct hit to the head.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>7. Being knocked unconscious always causes permanent damage to the brain.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>8. Symptoms of a concussion can last for several weeks.</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
9. Sometimes a second concussion can help a person remember things that were after the first concussion. (9)

10. Weightlifting helps to tone and/or build muscle. (10)

11. After a concussion occurs, brain imaging (e.g., CAT Scan, MRI, X-Ray, etc.) typically shows visible physical damage (e.g., bruise, blood clot) to the brain. (11)

12. If you receive one concussion and you have never had a concussion before, you will become less intelligent. (12)

13. After 10 days, symptoms of a concussion are usually completely gone. (13)

14. After a concussion, people can forget who they are and not recognize others but be perfect in every other way. (14)

15. Concussions can sometimes lead to emotional disruptions. (15)

16. An athlete who gets knocked out after getting a concussion is experiencing a coma. (16)

17. There is rarely a risk to long-term health and well-being from multiple concussions. (17)

Please read each of the following scenarios and select TRUE or FALSE
Q18 Scenario 1: While playing in a game, Player Q and Player X collide with each other and each suffers a concussion. Player Q has never had a concussion in the past. Player X has had four concussions in the past.

It is likely that Player Q's concussion will affect his long-term health and well-being. True False

It is likely that Player X's concussion will affect his long-term health and well-being. True False

Q19 Scenario 2: Player F suffered a concussion in a game. He/she continued to play in the same game even though they continued to feel the effects of the concussion.

Even though Player F is still experiencing the effects of the concussion, he/she performance will be the same as it would be had they not suffered a concussion.

True False

**Concussion Symptoms**

Q20 Think about someone who has had a concussion. Select the following signs and symptoms that you believe someone may be likely to experience AFTER a concussion.

- Hives
- Feeling in a “Fog”
- Headache
- Weight Gain
- Difficulty Speaking
- Feeling Slowed Down
- Arthritis
- Reduced Breathing Rate
- Sensitivity to Light
- Excessive Studying
- Difficulty Remembering
- Difficulty Concentrating
- Panic Attacks
- Dizziness
- Drowsiness
Appendix 4 - Scoring Key for Concussion Knowledge Index (CKI)

<table>
<thead>
<tr>
<th>Section</th>
<th>Correct Response 1</th>
<th>Correct Response 2</th>
<th>Correct Response 3</th>
<th>“Safer” Response 1</th>
<th>“Safer” Response 2</th>
<th>“Safer” Response 3</th>
<th>Symptom</th>
<th>Distractor! Legitimate Index</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>TRUE CKI</td>
<td>FALSE CKI</td>
<td>TRUE CKI</td>
<td>SD/D CAI</td>
<td>SA/A CAI</td>
<td>Hives</td>
<td>D</td>
<td>NI</td>
</tr>
<tr>
<td>2</td>
<td>FALSE NI</td>
<td>TRUE CKI</td>
<td>TRUE CKI</td>
<td>SA/A CAI</td>
<td>SA/A CAI</td>
<td>Headache</td>
<td>L</td>
<td>CKI</td>
</tr>
<tr>
<td>3</td>
<td>TRUE CKI</td>
<td>FALSE CKI</td>
<td>TRUE CKI</td>
<td>SA/A NI</td>
<td>SD/D CAI</td>
<td>Difficulty Speaking</td>
<td>D</td>
<td>CKI</td>
</tr>
<tr>
<td>4</td>
<td>TRUE VS</td>
<td>FALSE CKI</td>
<td>TRUE CKI</td>
<td>SA/A NI</td>
<td>SD/D CAI</td>
<td>Arthritis</td>
<td>D</td>
<td>NI</td>
</tr>
<tr>
<td>5</td>
<td>FALSE CKI</td>
<td>TRUE CKI</td>
<td>TRUE CKI</td>
<td>SD/D CAI</td>
<td>SD/D CAI</td>
<td>Sensitivity to Light</td>
<td>L</td>
<td>CKI</td>
</tr>
<tr>
<td>6</td>
<td>FALSE CKI</td>
<td>TRUE CKI</td>
<td>TRUE CKI</td>
<td>SD/D CAI</td>
<td>SD/D CAI</td>
<td>Difficulty Remembering</td>
<td>L</td>
<td>CKI</td>
</tr>
<tr>
<td>7</td>
<td>FALSE CKI</td>
<td>TRUE CKI</td>
<td>TRUE CKI</td>
<td>SA/A CAI</td>
<td>SA/A CAI</td>
<td>Panic Attacks</td>
<td>D</td>
<td>NI</td>
</tr>
<tr>
<td>8</td>
<td>TRUE CKI</td>
<td>FALSE CKI</td>
<td>TRUE CKI</td>
<td>SA/A CAI</td>
<td>SA/A CAI</td>
<td>Drowsiness</td>
<td>L</td>
<td>CKI</td>
</tr>
<tr>
<td>9</td>
<td>FALSE CKI</td>
<td>TRUE CKI</td>
<td>TRUE CKI</td>
<td>SA/A CAI</td>
<td>SA/A CAI</td>
<td>Feeling in a “Fog”</td>
<td>L</td>
<td>CKI</td>
</tr>
<tr>
<td>10</td>
<td>TRUE VS</td>
<td>FALSE CKI</td>
<td>TRUE CKI</td>
<td>SA/A CAI</td>
<td>SA/A CAI</td>
<td>Weight Gain</td>
<td>D</td>
<td>NI</td>
</tr>
<tr>
<td>11</td>
<td>FALSE CKI</td>
<td>TRUE CKI</td>
<td>TRUE CKI</td>
<td>SA/A CAI</td>
<td>SA/A CAI</td>
<td>Feeling Slowed Down</td>
<td>L</td>
<td>CKI</td>
</tr>
<tr>
<td>12</td>
<td>FALSE CKI</td>
<td>TRUE CKI</td>
<td>TRUE CKI</td>
<td>SA/A CAI</td>
<td>SA/A CAI</td>
<td>Reduced Breathing Rate</td>
<td>D</td>
<td>NI</td>
</tr>
<tr>
<td>13</td>
<td>TRUE CKI</td>
<td>FALSE CKI</td>
<td>TRUE CKI</td>
<td>SA/A CAI</td>
<td>SA/A CAI</td>
<td>Excessive Studying</td>
<td>D</td>
<td>NI</td>
</tr>
<tr>
<td>14</td>
<td>FALSE CKI</td>
<td>TRUE CKI</td>
<td>TRUE CKI</td>
<td>SA/A CAI</td>
<td>SA/A CAI</td>
<td>Difficulty Concentrating</td>
<td>L</td>
<td>CKI</td>
</tr>
<tr>
<td>15</td>
<td>FALSE VS</td>
<td>TRUE CKI</td>
<td>TRUE CKI</td>
<td>SA/A CAI</td>
<td>SA/A CAI</td>
<td>Dizziness</td>
<td>L</td>
<td>CKI</td>
</tr>
<tr>
<td>16</td>
<td>TRUE CKI</td>
<td>FALSE CKI</td>
<td>TRUE CKI</td>
<td>SA/A CAI</td>
<td>SA/A CAI</td>
<td>Hair Loss</td>
<td>D</td>
<td>NI</td>
</tr>
</tbody>
</table>

\*CKI = Concussion Knowledge Index; CAI = Concussion Attitude Index; VS = Validity Scale; NI = no index—item not part of any index. \*SD/D = strongly disagree/disagree; SA/A = strongly agree/agree. \*L = legitimate symptom; D = distractor symptom.
### Appendix 5 - CKI Questions and Participant Responses

<table>
<thead>
<tr>
<th>Concussion Knowledge Index (CKI) item</th>
<th>Concussion History</th>
<th>Correct Responses</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Section 1 Concussion Knowledge - 14 Statements – True / False</strong></td>
<td>Yes (n=23)</td>
<td>No (n=53)</td>
</tr>
<tr>
<td>There is a possible risk of death if a second concussion occurs before the first one has healed. (T)</td>
<td>22 (95.7%)</td>
<td>52 (98.1%)</td>
</tr>
<tr>
<td>People who have had one concussion are more likely to have another concussion. (T)</td>
<td>20 (87.0%)</td>
<td>48 (90.6%)</td>
</tr>
<tr>
<td>In order to be diagnosed with a concussion, you have to be knocked out. (F)</td>
<td>23 (100%)</td>
<td>53 (100%)</td>
</tr>
<tr>
<td>A concussion can only occur if there is a direct hit to the head. (F)</td>
<td>23 (100%)</td>
<td>48 (90.6%)</td>
</tr>
<tr>
<td>Being knocked unconscious always causes permanent damage to the brain. (F)</td>
<td>18 (78.3%)</td>
<td>44 (83.0%)</td>
</tr>
<tr>
<td>Symptoms of a concussion can last for several weeks. (T)</td>
<td>23 (100%)</td>
<td>53 (100%)</td>
</tr>
<tr>
<td>Sometimes a second concussion can help a person remember things that were forgotten after the first concussion. (F)</td>
<td>21 (91.3%)</td>
<td>44 (83.0%)</td>
</tr>
<tr>
<td>After a concussion occurs, brain imaging (e.g., CAT Scan, MRI, X-Ray, etc.) typically shows visible physical damage (e.g., bruise, blood clot) to the brain. (F)</td>
<td>14 (60.9%)</td>
<td>22 (41.5%)</td>
</tr>
<tr>
<td>If you receive one concussion and you have never had a concussion before, you will become less intelligent. (F)</td>
<td>22 (95.7%)</td>
<td>53 (100%)</td>
</tr>
<tr>
<td>After 10 days, symptoms of a concussion are usually completely gone. (T)</td>
<td>3 (13.0%)</td>
<td>6 (11.3%)</td>
</tr>
<tr>
<td>After a concussion, people can forget who they are and not recognize others but be perfect in every other way. (F)</td>
<td>11 (47.83%)</td>
<td>17 (32.1%)</td>
</tr>
<tr>
<td>Concussions can sometimes lead to emotional disruptions. (T)</td>
<td>23 (100%)</td>
<td>53 (100%)</td>
</tr>
<tr>
<td>An athlete who gets knocked out after getting a concussion is experiencing a coma. (T)</td>
<td>0 (0.0%)</td>
<td>9 (17.0%)</td>
</tr>
<tr>
<td>There is rarely a risk to long-term health and well-being from multiple concussions. (F)</td>
<td>20 (87.0%)</td>
<td>49 (92.5%)</td>
</tr>
</tbody>
</table>

### Section 2 – 3 Scenarios – True / False

**Scenario 1:** While playing in a game, Player Q and Player X collide with each other and each suffers a concussion. Player Q has never had a concussion in the past. Player X has had 4 concussions in the past.

- It is likely that Player Q’s concussion will affect his long-term health and well-being. (F) | 17 (72.9%) | 39 (73.6%) |
- It is likely that Player X’s concussion will affect his long-term health and well-being. (T) | 23 (100%) | 53 (100%) |

**Scenario 2:** Player F suffered a concussion in a game. She continued to play in the same game despite the fact that she continued to feel the effects of the concussion.

- Even though Player F is still experiencing the effects of the concussion, her performance will be the same as it would be had she not suffered a concussion. (F) | 22 (95.7%) | 50 (94.3%) |

### Section 3  Symptom Recognition – Select Correct Symptoms

<table>
<thead>
<tr>
<th>Symptom</th>
<th>Yes (n=23)</th>
<th>No (n=53)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Headache</td>
<td>23 (100%)</td>
<td>53 (100%)</td>
</tr>
<tr>
<td>Sensitivity to light</td>
<td>23 (100%)</td>
<td>52 (98.1%)</td>
</tr>
<tr>
<td>Difficulty remembering</td>
<td>22 (95.7%)</td>
<td>48 (90.6%)</td>
</tr>
<tr>
<td>Drowsiness</td>
<td>19 (82.6%)</td>
<td>44 (83.0%)</td>
</tr>
<tr>
<td>Feeling in a “fog”</td>
<td>21 (91.3%)</td>
<td>47 (88.7%)</td>
</tr>
<tr>
<td>Feeling slowed down</td>
<td>22 (95.7%)</td>
<td>48 (90.6%)</td>
</tr>
<tr>
<td>Difficulty concentrating</td>
<td>23 (100%)</td>
<td>50 (94.3%)</td>
</tr>
<tr>
<td>Dizziness</td>
<td>23 (100%)</td>
<td>50 (94.3%)</td>
</tr>
</tbody>
</table>
Section 4  Distractor Symptoms – symptoms not selected

<table>
<thead>
<tr>
<th>Symptom</th>
<th>% of Population</th>
<th>% of Sample</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hives</td>
<td>23 (100%)</td>
<td>53 (100%)</td>
</tr>
<tr>
<td>Weight Gain</td>
<td>20 (87.0%)</td>
<td>48 (90.6%)</td>
</tr>
<tr>
<td>Difficulty Speaking</td>
<td>9 (39.1%)</td>
<td>18 (34.0%)</td>
</tr>
<tr>
<td>Arthritis</td>
<td>23 (100%)</td>
<td>53 (100%)</td>
</tr>
<tr>
<td>Reduced Breathing Rate</td>
<td>21 (91.3%)</td>
<td>43 (81.1%)</td>
</tr>
<tr>
<td>Excessive Studying</td>
<td>22 (95.7%)</td>
<td>52 (98.1%)</td>
</tr>
<tr>
<td>Panic Attacks</td>
<td>14 (60.9%)</td>
<td>38 (71.7%)</td>
</tr>
<tr>
<td>Hair Loss</td>
<td>23 (100%)</td>
<td>53 (100%)</td>
</tr>
</tbody>
</table>

Section 5 - Overall CKI Score (not including distractors)- possible score/25

<table>
<thead>
<tr>
<th>Score</th>
<th>% of Population</th>
<th>% of Sample</th>
</tr>
</thead>
<tbody>
<tr>
<td>20.9</td>
<td>(83.6%)</td>
<td></td>
</tr>
<tr>
<td>20.5</td>
<td>(82.0%)</td>
<td></td>
</tr>
</tbody>
</table>
Appendix 6 – Knowledge-to-Action (KTA) Framework to Sport Concussion Example

(KTA) framework to sport concussion example (Provvidenza, et al., 2013)