Reasons for Concussion Under-reporting in Varsity Athletes: A Mixed Methods Approach

By

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Abstract

Sport-related concussion is an increasing challenge for student-athletes, medical staff, and faculties to manage in post-secondary institutions. Delayed assessment and management leads to increased time away from class and sport, and low reporting rates among athletes contribute to poor recovery rates and potential long-term consequences. The purpose of this study was to utilize a mixed-methods approach to examine concussion education, attitudes, and reporting intention and behaviour, to explore reasons why varsity athletes fail to report concussions.

Results indicated that athlete knowledge of signs and symptoms of concussion is very high, but that decision-making process that athletes undergo to report concussions leads to unsafe reporting behaviours. Themes of knowledge, non-reporting influences, and high thresholds to report create complex inter- and intra-personal messages that over-ride education and lead to non-reporting of concussions.

The results of this study suggest that education programs need to address the influence of sport-culture, personal attitudes and beliefs, and external messages that varsity athletes receive in order to improve reporting rates.

Key Terms

Concussion, Sport, Education, Mixed-Methods, Symptom Reporting

Statement of Originality

I, Jessica E. Salt, hereby declare that this thesis represents my own work, except as acknowledged in the text. I further declare that the material contained in this thesis has not been previously submitted, either in whole or in part, for a degree at this or any other university.

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Table of Contents

List of Tables

List of Figures

List of Abbreviations Used

ARU – Australian Rugby Union

ATP – Adenosine Triphosphate

BESS – Balance Error Scoring System

CBF – Cerebral Blood Flow

CBV - Cerebral Blood Volume

CCTI - Capacity to Consent to Treatment Instrument

CIS – Canadian Interuniversity Sport

CT – Computed Tomography

CTE – Chronic Traumatic Encephalopathy

DAI – Diffuse Axonal Injury

DL- PFC - Dorso-Lateral Prefrontal Cortex

DTI – Diffusion Tensor Imaging

FA – Fractional Anisotropy

fMRI - Functional Magnetic Resonance Imaging

GCS – Glasgow Coma Scale

GSC – Graded Symptom Checklist

HIQ – Head Injury Questionnaire

HIS – Head Injury Scale

ICC – Intra-class Correlation Coefficient

IGT – Iowa Gambling Task

ImPACT – Immediate Post-Concussion Assessment and Cognitive Test

LOC – Loss of Consciousness

MD – Mean Diffusivity

mTBI – Mild Traumatic Brain Injury

MTT - Mean Transit Time

NCAA – National Collegiate Athletic Association

NHL – National Hockey League

OUA – Ontario University Athletics

PCS – Post Concussion Syndrome

PCSS – Post-Concussion Symptom Scale

PGH – Player Game Hours

PTSD – Post-Traumatic Stress Disorder

RoCKAS-ST – Rosenbaum Concussion Knowledge and Attitudes Survey—Student Version

SCAT3 – Sport Concussion Assessment Tool

SIS – Second Impact Syndrome

TBI - Traumatic Brain Injury

UOIT – University of Ontario Institute of Technology

VBM – Voxel-Based Morphography

VMF – Ventromedial Prefrontal Cortex

Chapter 1 – Introduction & Literature Review

Introduction

Concussion incidence in sport is a growing cause for concern, both by the medical community and athletes themselves. Researchers estimate that between 1.6 and 3.8 million sport-related concussions occur each year in the United States (Langlois, Rutland-Brown, & Wald, 2006), and in Canada, 1 in 5 sport related injuries are concussions ("Causes of Acquired Brain Injury", n.d.). High-profile athlete deaths and the increased awareness of chronic traumatic encephalopathy (CTE) have kept concussions in the media spotlight and increased awareness in the general and sport populations. To date, there are no objective biological markers to diagnose concussion, instead, sport-related concussions are often assessed on field using somatic and cognitive symptoms, emotional changes, and physical signs (P. McCrory et al., 2013).

Team medical staff are often required to make return to play decisions around teammates, coaches, and in a busy on-field setting using sideline evaluation tools and brief observation of the athlete. Unfortunately, athletes are often allowed to return to play too early after suffering a concussion, or their concussion is not recognized in the first place; meaning that they continue playing and subjecting them to possible long-term negative consequences. Extensive research has been conducted on how to effectively assess and manage concussions, and the evolving understanding of the pathophysiological processes that occur in both the acute and recovery phases of concussion continues to improve assessment and management tools. However, in many cases concussion assessment relies on the reporting of symptoms by the athlete themselves, and athletes for many reasons may not report their symptoms to coaches or medical staff, which may result in athletes returning to play too early.

Most patients who experience a concussion recover within seven to ten days, however approximately 10% experience persistent symptoms (Leddy, Sandhu, Sodhi, Baker, & Willer, 2012), which can profoundly affect normal activities. Student-athletes who suffer a concussion are not only removed from participation in sport, they are often advised to stop attending classes, and defer tests and assignments. In a short 10-12 week term,

losing time from class may negatively affect their academic performance. This removal from school and sport may contribute to the underreporting of concussions among university-level athletes, but little research has been conducted to date that investigates reporting intentions and behaviour while also allowing athletes to discuss, in their own words, reasons why they do not report their symptoms.

Literature Review

What is Concussion

As a category of mild traumatic brain injury (mTBI), concussion is defined as "a complex pathophysiological process affecting the brain, induced by biomechanical forces"(P. McCrory et al., 2013), whose symptoms may present immediately after injury, or be delayed until hours after the time of injury.. Symptoms can include, but are not limited to; headache, dizziness, disorientation, confusion, visual disturbances, and clinical signs like vomiting and loss of consciousness. In sport-related concussion, diagnosis is made when an athlete demonstrates any mental status change following a traumatic force to the head or body (Fazio, Lovell, Pardini, & Collins, 2007).

Previous definitions of concussion utilized loss of consciousness as a marker to determine severity or even diagnosis of concussion (Cantu, 2001; Collins, Lovell, & Mckeag, 1999; Neurology, 1997). The current definition, as created by experts in the field of concussion assessment and management, specifically notes that loss of consciousness is not a determining factor in concussion assessment (P. McCrory et al., 2013).

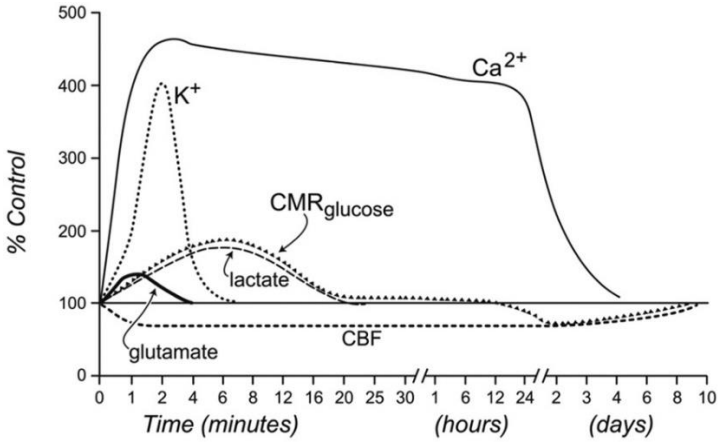
Pathophysiology of Concussion

The pathophysiology of concussion is a highly complex cascade of physiologic, metabolic and ionic factors, which combine to create the impairments experienced by the sufferer. Immediately after injury to the brain, the neural membrane is disrupted and neurotransmitters are released and ionic fluxes occur (Giza & Hovda, 2001), which leads to neuronal depolarization with potassium (K^+) leaving and a calcium (Ca^{2+}) influx. This shift of ions leads to both acute and subacute changes in cellular physiology (Giza & Hovda, 2001). As extracellular K^+ increases, neuronal depolarization is triggered in diffuse areas of the brain. In the acute stages, the sodium-potassium (Na^+-K^+) pump works to restore the membrane potential within the neuron and ionic homeostasis,

requiring an excess amount of adenosine triphosphate (ATP), thus leading to an increase in glucose metabolism. A cellular energy crisis is created through the requirement of increased glucose (hyper-metabolism) within a setting of decreased blood flow; leading to a disparity between energy supply and demand (Giza & Hovda, 2001). In the subacute phase, mitochondrial metabolism decreases as a result of increased calcium levels and the energy crisis worsens. Neural connectivity may be affected as neurofilaments and microtubules are disrupted by the calcium influx into the axon. Increased metabolism (glycolysis) leads to increased lactate production, which, combined with decreased lactate metabolism results in lactate accumulation. Further neuronal dysfunction may occur as a result of lactate accumulation which causes acidosis, membrane damage, altered blood-brain permeability, and cerebral edema (Giza & Hovda, 2001).

Upon biomechanical injury to the brain, mechanical stretching of axons may occur, leading to membrane disruption and depolarization. The disruption causes the effects discussed above and affects the neurochemical cascade that results from the impact. The increased permeability can last for up to 6 hours post injury (Giza & Hovda, 2001), and can lead to a number of effects, including influx of calcium (Ca^{2+}) and mitochondrial swelling. The increased levels of Ca^{2+} impair mitochondrial metabolism and can lead to cell death. Experimental concussion testing has demonstrated that Ca^{2+} accumulation peaks in 2 days and resolves by day 4 in moderate concussion, with no structural damage (Fineman, Hovda, Smith, Yoshino, & Becker, 1993). The same studies show that more severe concussion testing (in animals) causes structural damage within the brain and ongoing neuronal death. The neuronal dysfunction, whether permanent or transient, leads to the clinical signs and symptoms experienced by the injured athlete and recovery is both complex and varied between individuals, with most signs and symptoms resolved in 7-10 days (P. McCrory et al., 2013). The timing of the neurometabolic cascade of concussion is shown in Figure 1, demonstrating that in most cases, the neurochemical, ionic, and metabolic changes have returned to baseline levels after 10 days.

Figure 1: Timing of Neurochemical Recovery After Concussion



K+ - Potassium
CMRglucose – Cerebral metabolic rate of glucose utilization
Ca^2+ - Calcium
CBF – Cerebral blood flow

Image from Leddy et al. (2012)

Imaging Studies

Lesions are not generally visible on conventional neuroimaging when assessing mTBI, and more specifically, sport-related concussions. However, an increasing number of studies are finding lesions or reduced functioning in certain areas of the brain when using more advanced imaging techniques (Chen, Kareken, Fastenau, Trexler, & Hutchins, 2003; De Beaumont, Henry, & Gosselin, 2012; de Guise et al., 2010; Mannix et al., 2013; Pulsipher, Campbell, Thoma, & King, 2011). Metting et.al. found that when comparing healthy controls to acutely injured mTBI patients using perfusion computed tomography (CT), decreased mean transit time (MTT) and cerebral blood flow (CBF) occurred in frontal white and grey matter, and cerebral blood volume (CBV) was decreased in the occipital grey matter (Metting et al., 2009). Interestingly, those patients with a Glasgow Coma Scale (GCS) of 15 upon initial assessment were found to have an increased CBF in the frontal and occipital white matter. Most athletes with sport-induced concussion would present to a physician with a GCS of 15, which traditionally indicated little damage, however, Metting's research shows that this may not in fact be the case.

Recent research has examined the theory that concussion or mTBI can cause diffuse axonal injury (DAI) to the white matter of the brain while leaving the majority of the grey matter unaffected. White matter structural changes can be seen using Diffusion Tensor

Imaging (DTI), so it has been used to detect injuries in patients with otherwise normal imaging, however results have been inconsistent. In a meta-analysis performed in 2012, Aoki et al found significantly reduced fractional anisotropy (FA), (which quantifies the orientation and integrity of white matter tracts) and increased mean diffusivity (MD) (an inverse measure of the membrane density) in the corpus callosum of concussed participants compared with controls (Aoki, Inokuchi, Gunshin, Yahagi, & Suwa, 2012). These findings would demonstrate that the corpus callosum, the main fibre tract that connects the hemispheres, experiences changes in cellular membrane integrity, fibre myelination, and directionality after mTBI (Aoki et al., 2012).

In 2010 Messé et.al. found white matter lesions in long association fasciculi connecting the frontal, parietal, and temporal cortices using Voxel-Based Morphometry (VBM) and DTI (Messé et al., 2011). Similar white matter disruptions have been found in research on hockey players (Helmer et al., 2014; Pasternak et al., 2014; Sasaki et al., 2014) and other mTBI patients (Slobounov et al., 2010; Smits et al., 2011).

Using fMRI (Functional Magnetic Resonance Imaging), increased neural activity and recruitment of dorso-lateral prefrontal cortex (DL-PFC) during spatial navigation tasks was seen in a study by Slobounov et.al. (2010). The researchers hypothesized that the increases reflect compensatory mechanisms that occur with structural or functional disturbances to the default network in some regions of the brain (Zhang et al., 2010).While it is unrealistic to expect that hospitals and physicians will have access to fMRI and perfusion CT for all mTBI assessments, hopefully the awareness that damage is occurring (even in injuries with minimal subjective and cognitive findings), first-line medical personnel will be better equipped to manage athletes with concussion.

Concussion Assessment

While neuroimaging studies continue to advance the knowledge of the presence of even the smallest lesion after mild brain injury, athletes, coaches, field-side medical personnel, and clinicians are often still tasked with the job of determining an athlete's readiness to return to play after concussion. The science of concussion is evolving, with much research focused on assessment tools to be used both on the field and clinically to evaluate concussed athletes. Unfortunately, the nature of concussion and the current understanding of concussion assessment mean that management and return to play decisions are often made by using clinical judgement in the absence of concrete, objective tests. Upon neuropsychological investigation, often deficits are not found, and when they are, they are usually in the executive domain (Smits et al., 2011). Traditional neuroimaging in the acute and post-acute phase of mTBI doesn't usually reveal evidence of brain damage (Ettenhofer & Abeles, 2009), however, mTBIs account for 70-90% of all hospital treatment for traumatic brain injuries (Cassidy et al., 2004). This is one of the reasons why concussion has traditionally been described as a functional rather than structural disturbance of the brain.

The diagnosis and management of sport-related concussion is a growing problem for medical practitioners, who must struggle with the lack of availability of objective testing while having to trust athletes to honestly report their subjective symptoms. As a result, research into neuropsychological testing tools has become critical for the "real-world" diagnosis of concussion, and subsequent return to play decisions. Many tools are available to medical practitioners to aid in the evaluation of concussion clinically and in the field, yet there is no standardized tool or set of tests that have been shown to be effective, valid, and objective assessment for all ages, sexes and cohorts of athletes. Consequently, diagnosis, treatment and return to play decisions after concussion in sport are based on clinical judgement, subjective data, neuropsychological testing, and "best practices", and rely on the skills of the medical professional at teasing out the important information from all tests and interviews. Extensive research has been

performed on a number of different tests and protocols used in the assessment of concussion in athletes, and yet there is still no definitive testing procedure for medical professionals to utilize.

Baseline Testing

The current consensus statement on concussion, developed in Zurich in 2012, recommends that sport concussion management take a multifaceted approach, including symptom scales, balance assessments and neurocognitive testing in the assessment of the injury, and for subsequent return to play decisions (P. McCrory et al., 2013). One method that can be used to assist in post-injury concussion assessment is the use of baseline testing, which has been generally agreed upon to be needed and beneficial for neuropsychological concussion assessment (Aubry et al., 2002; P. McCrory et al., 2009). These baseline tests take on many forms, from paper and pencil symptom scales and neurocognitive tests, to computer-based and interview–type models, all with the goal of establishing a "normal" set of scores that can be used when an athlete has suffered a suspected concussion to determine if there has been a deviation from this (presumably healthy) baseline set of scores. VanKampen and colleagues found that symptom report combined with neuropsychological testing correctly identified 94% of concussed athletes compared to symptom reporting alone, which confirmed only 65% of concussed athletes (Van Kampen, Lovell, Pardini, Collins, & Fu, 2006).

Self-Reporting Scales

As previously mentioned, baseline testing comes in many forms, but for the purpose of this paper, self-reporting scales and computer-based neurocognitive testing will be discussed. A self-reporting scale allows athletes to report their symptoms, usually along with a severity rating, on a Likert-type scale. A common self-reporting scale is the Post-Concussion Symptom Scale (PCSS), which displays an internal consistency of 0.88 in healthy, non-concussed athletes, and 0.94 in recently concussed athletes (Mark R Lovell et al., 2006). The checklist has also been shown to be reliable and valid for the assessment of both symptoms presence and severity (Guskiewicz et al., 2013).

Optimally, a baseline set of symptoms would be obtained prior to an athlete's season, which would allow direct comparison with post-concussion values. Unfortunately bias may exist due to athletes being unmotivated to return to play (and therefore report symptoms that they do not have), or conversely, athletes may fake an absence of symptoms in order to return to play before they are fully healed (M McCrea et al., 2003). A major fault with relying solely on symptom reporting scales is that some post-concussive symptoms may exist in people who have not sustained a concussion. When examining the structural validity of a self-reported symptom scale, Piland et.al. asked 1089 healthy, non-concussed high school football players to fill out the Graded Symptom Checklist (GSC), a scale that asks whether the subject is experiencing any symptoms (in a list of 16 symptoms) on the date of testing, and if yes, to rate the severity of each symptom. Interestingly, the results showed that athletes report concussion-related symptoms on non-concussed preseason baseline tests (Piland, Motl, Guskiewicz, McCrea, & Ferrara, 2006). This has implications for the use of the GSC for post-concussion testing, as it would be difficult for the practitioner to determine if the symptoms were concussion-related or not. However, this research found that these symptoms are reported in a predictable scoring structure, and create a cohesive group of 9 symptoms that fit into one of 3 domains: somatic symptoms, neurobehavioural symptoms, and cognitive symptoms (Piland et al., 2006). Therefore, even though non-concussed individuals report symptoms, there is strong support for the structural validity of the scale itself. In further research Piland and colleagues examined the 9-item Head Injury Scale (HIS), a Likert-type scale designed to measure the duration a symptom is experienced, and the PCSS to capture the severity of each symptom. Similar to his study performed in 2006, this research found that baseline scores were inflated in some individuals, specifically in those with a history of concussion, current illness or injury, or fatigue (Piland, Ferrara, Macciocchi, Broglio, & Gould, 2010). However, baselines were consistent internally and across time, and factorially valid when confounding variables (concussion history, illness/injury, and fatigue) were removed. Following this research, Piland et al. recommended that when utilizing symptom-reporting scales, care must be

taken to note the variables which will inflate baseline scores in an absence of a concussion, and clinicians should provide an opportunity for athletes to report their concussion history, and presence of fatigue, illness or injury before completing a baseline exam. This will allow baseline testing to be deferred until the controllable variables have resolved and a more accurate result obtained (Piland et al., 2010). Therefore, based on these findings, future research by this author must address the limitations of the self-reporting scale and evaluate pre-season baseline tests by athletes in order to determine the existence of confounding variables, and concussion-related symptoms in the absence of injury.

Neurocognitive Testing

Another type of baseline testing is computer-based neurocognitive testing, which is increasingly being used by school-based, amateur and professional teams as a user-friendly, easily-administered, objective tool to quantify neurocognitive impairments. These tools then create objective information that medical professionals can use in their diagnosis of concussion. In order to be an effective tool, neurocognitive testing must be valid and sensitive to the effects of a concussive injury. Previously, paper and pencil tests were used with athletes – given their cost-effectiveness and ease of administration, they were extensively administered with athletes of all ages and skill levels. However, paper and pencil tests have been shown to not have enough normative data, high enough sensitivity or specificity, and are vulnerable to practice effects (P. Schatz, Pardini, Lovell, Collins, & Podell, 2006).

One computer-based test is the Immediate Post-Concussion Assessment and Cognitive Test (ImPACT) that incorporates demographic information, neurocognitive tests and the PCSS to provide baseline scores. It is also used post-injury to create a set of scores that can be compared to baseline and normative data. The ImPACT test uses 6 modules in the neurocognitive test battery to give 5 index scores – verbal memory, visual memory, visual motor speed, reaction time, and impulse control. Verbal memory represents the average percent correct for word recognition, symbol number match and letter memory

(with an interference task), while the visual memory score is comprised of an average correct of discrimination of a series of abstract line shapes and X's and O's with an accompanying intervening task. Reaction time represents the average response time on choice reaction time, go/no go, and symbol match tasks; whereas processing speed is the weighted average of interference tasks for the memory scores. Finally, the impulse control score represents the total number of errors of omission or commission on the go/no go and choice reaction time tasks (Lovell, 2015). The ImPACT battery also includes the previously discussed PCSS, which allows the subject to report the presence of 22 commonly reported symptoms (e.g. headache, fogginess, fatigue) and their severity, and demographic data to allow the reporting of previous head injuries, learning disabilities and speech and brain pathologies. Studies have shown that the sensitivity of the ImPACT test is 81.9% and the specificity 89.4%, so poor performance on any of the composite scores indicates a high likelihood of reflecting a concussion (P. Schatz et al., 2006).

The ImPACT test is shown not to have the same practice effects as paper and pencil testing (M. Lovell, Collins, & Bradley, 2004), as it has 5 different post-injury test batteries with the potential for creating new combinations. Initially the ImPACT test was administered using a desktop version; however in 2008 an online version was introduced. A study by Shatz et.al. in 2012 showed fewer invalid tests with the online version than the desktop-based test – mostly due to the change in the left-right selection test, which switched from a mouse-based test (on the desktop version), to a one that utilizes a keyboard instead (P. Schatz, Moser, Solomon, Ott, & Karpf, 2012). His research showed that the validity of the ImPACT test was improved (and fewer invalid tests were reported) with the online version for both high school and collegiate-aged athletes. Another benefit of the ImPACT test is its use of internal markers to pinpoint invalid tests, so that the medical practitioner needn't have extensive neuropsychological training in order to administer test and interpret the results. The internal markers look for scores further than 2 standard deviations from the normative data on each domain and "red flag" those tests (Lovell, 2015). These flagged results can be indicative of an

athlete attempting to purposely perform poorly on the test at baseline, in the assumption that post-injury results would not show as large of a decline, or of an athlete who did not understand the instructions of the test. In order to test the sensitivity of the ImPACT test to athletes who intentionally perform poorly or "sandbag" the test, Erdal asked 75 collegiate athletes (33 men and 42 women) to intentionally perform poorly on the test without triggering the program to red flag their scores (i.e. not perform worse than 2 standard deviations below the norm). When the results were examined, 11% of the subjects were able to "successfully" fake poor results – they scored worse than their baseline without exceeding the threshold to trigger the test to become invalid. It was found that men, athletes who played contact sports, and those with a history of concussion were least successful at faking their poor results. The overall findings of this study were that it is difficult for athletes to purposely "sandbag" their ImPACT test – with 89% being unsuccessful and triggering the red flag built in to the test, even when motivated, instructed, and experienced with taking the test (Erdal, 2012). These findings bode well for the use of the ImPACT program to detect cognitive deficiencies in athletes who may not report symptoms, or who are highly motivated to purposely perform poorly on the baseline test in order to confound future post-injury testing.

Previous research has indicated that the average time between baseline testing and post-concussion evaluation is 45 days (Unpublished data, University of Georgia, Dept. of Sports Medicine, 2005), which is important for researchers attempting to assess the validity and reliability of the tool for real-life applications. Lovell and colleagues examined the effects of concussion on neurocognitive performance in high school athletes (Mark R Lovell et al., 2003), and compared baseline scores to post-concussion scores in injured athletes. Non-concussed controls were also examined at baseline, and re-tested at 7, 9, and 11 day intervals. Based on the findings at the University of Georgia, the arbitrary selection of re-test times (as in Lovell's study) is not useful in accurately assessing the re-test reliability of the ImPACT test. Consequently, in 2007 Broglio and colleagues assessed the test-retest reliability of three different computer-based neurocognitive testing programs – the ImPACT battery, the Headminder

Concussion Resolution Index, and Concussion Sentinel, at clinically relevant baseline, 45, and 50-day intervals. In this research, 118 university students with no history of concussion, learning disability or Attention Deficit Hyperactivity Disorder were administered the 3 neurocognitive tests in groups of fewer than 5 people. Using recommended guidelines for Intra-class Correlation Coefficient (ICC) values to be above 0.60 for minimal acceptance (above 0.75 indicates good reliability), the test-retest reliabilities for all indexes on all 3 tests were found to be below accepted levels for making accurate clinical evaluations (Broglio, Ferrara, Macciocchi, Baumgartner, & Elliott, 2007). Specifically, from baseline to day 45, and from day 45-50 the ICC for the ImPACT output scores are displayed in Table 1. Reliability increased on all scores in the 5 day interval between day 45 and 50, however, as a clinical tool used between baseline and the average interval between baseline and injury of 45 days, based on this research, it would appear that the ImPACT battery is not a reliable tool. Another important finding of this study is that 20-40% of all subjects were identified as being impaired on at least 1 variable during the follow-up evaluations (as opposed to previous findings of only 7-9% impairment on paper and pencil tests), which, in the absence of concussion, must be a result of other variables (Broglio et al., 2007).

Table 1: Intra-class Correlation Coefficients for ImPACT Test Output Scores

	Verbal Memory	Visual Memory	Visual-Motor Speed	Composite Reaction Time	Impulse Control
Baseline → Day 45	0.23	0.32	0.38	0.39	0.15
Day 45 → Day 50	0.40	0.39	0.61	0.51	0.54

Adapted from Lovell (2015)

Using the findings from Broglio's study in 2007, Schatz et al examined the long-term test-retest reliability of the ImPACT test. He used 95 collegiate athletes who were baseline tested using the ImPACT program, and then re-tested them 2 years later. Unlike Broglio, Schatz's study showed ImPACT follow up scores with considerable stability and ICCs ranging from 0.45 to 0.75 on the composite scales (Philip Schatz, 2010). While the test-re test interval in Schatz's study was much longer than that of Broglio, his test-re test reliability scores were much higher, and showed that baseline

testing can be stretched to 2 years (instead of the previously accepted 1 year interval). One compelling explanation for the improvement in the ICC scores is the use of only one test in Schatz's study. Unlike Broglio, whose subjects completed 3 similar test batteries in immediate succession, the subjects in Schatz's study only performed the ImPACT test, possibly eliminating confusion experienced by subjects completing 3 tests in one session.

However, as with all clinical testing, concussive symptoms must be recognized or revealed at or shortly after the time of injury in order to be effectively utilized to assess and manage concussions in athletes. Computer-based assessment tools are easily performed in a clinical setting, however, if an athlete does not reveal his or her symptoms, or athletes, parents or staff are not educated in the common signs and symptoms of concussion, the concussed athlete will not be referred to a clinic for subsequent testing.

Neurocognitive Deficits

The overall purpose of all types of neurocognitive testing, whether paper and pencil, interview-type, or computer-based, is to determine if any neurocognitive deficits exist in a concussed athlete regardless of reported symptoms. Using the ImPACT program, Fazio et al (2007) attempted to determine the relationship between post-concussion symptoms and neurocognitive deficits. She and her colleagues hypothesized that a symptomatic group of concussed athletes would display more neurocognitive deficits that those concussed athletes without symptoms, and a group of healthy control subjects. Specifically, 192 subjects (78 concussed-symptomatic, 44 concussed-asymptomatic, and 70 non-concussed controls) were tested using the ImPACT battery (Version 2.0) for which the two concussion groups were re-tested with 1 week post injury, and the control group was re-tested up to 11 days after baseline testing was performed. As expected, concussed-symptomatic athletes demonstrated significantly poorer performance on all domains (verbal memory, visual memory, reaction time and processing speed), than both concussed-asymptomatic and control groups. However, a

major finding of the study was that asymptomatic concussed athletes performed worse on all domains of the test than did the controls, indicating that even though no symptoms were reported, neurocognitive deficits still existed (Fazio et al., 2007). This is especially important for clinical applications of neurocognitive testing and self-reported symptom scales - athletes have many reasons for not reporting symptoms, and having a neurocognitive test that can reliably identify neurocognitive deficits is extremely important for medical personnel to identify concussed athletes.

Fazio's results are similar to a previous study by Collie et al. in 2006, who reported on cognitive test performance on concussed and non-concussed Australian Rules football players. Between 2001 and 2003, 615 players were baseline tested using the CogSport computer-based neurocognitive test and 2 paper and pencil neurocognitive tests. Over the course of those 3 seasons, 61 players were concussed and re-tested (25 symptomatic and 36 asymptomatic) within 11 days of their injury. As expected, the symptomatic group had a statistically large and significant cognitive decline, despite reporting minimal symptoms (the mean number of symptoms reported was 1.8), and the asymptomatic group showed deficits in the divided attention speed domain in the CogSport test. Interestingly, the control and asymptomatic groups actually improved their scores on the paper and pencil testing (when compared to baseline), and the symptomatic group showed similar scores to their baseline (Collie, Makdissi, Maruff, Bennell, & McCrory, 2006). Based on these results, it was demonstrated that not only are neurocognitive deficits still present when symptoms aren't reported, but paper and pencil neurocognitive testing are not accurately assessing the existing deficits in athletes.

On-Field Assessment Tools

Coaches and medical staff must be able to recognize and respond to potential concussions at the time of injury in order to manage the injury properly. To this end, objective measurement tools have been developed in the hope that athletes with concussion will be removed from play in a timely manner, while still allowing those who

have not suffered a brain injury to continue to play, even after what may appear to be an injury-causing mechanism.

One such tool is the Sport Concussion Assessment Tool (SCAT3), which utilizes a multimodal instrument that streamlines the assessment protocol. Concussion signs and symptoms are recognized and severity is recorded, followed by neurocognitive and balance testing. Utilizing the PCSS, potential symptoms are graded on a 7-point Likert scale, and if any of these factors are impaired, or if the athlete discloses any signs or symptoms that occurred as a result of a blow to the head or body that could transmit forces into the brain, he or she would be removed from play.

For balance testing, the SCAT3 utilizes the firm-surface portion of the Balance Error Scoring System (BESS), where balance is tested in 3 positions (single-leg, double-leg, and tandem-leg stances) on a hard surface and again on a foam surface. The inter-tester and intra-tester reliabilities of the BESS have been found to have anywhere from low to high values, depending on which study is cited; however, it has been shown to be sensitive to concussion (Guskiewicz et al., 2013). By utilizing memory, balance and coordination tests, as well as symptom reporting, the SCAT3 tool attempts to provide an effective method to quickly and reliably ascertain whether it is safe for an athlete to return to sport.

Consequences of Concussion

The importance of recognizing neurocognitive deficits cannot be understated – not only can it save athletes from the potential long-term consequences of post-concussion symptoms, it allows clinicians to effectively evaluate athletes despite lack of honest reporting of symptoms. These deficits occur as early as 2 hours post-injury and are maximized at 48 hours post injury (Echemendia & Julian, 2001), which is important because it is at this point that athletes often start to report a decline in subjective symptoms, but their brain function is still significantly impaired. This was illustrated by Echemendia and colleagues in 2001, when he found that athletes' report of symptoms

report of symptoms did not differ between concussed athletes and non-injured controls 48 hours following concussion, and yet there was a significant difference in neurocognitive functioning between the two groups (Echemendia, Putukian, Mackin, Julian, & Shoss, 2001).

Athletes with concussion commonly relate a common set of symptoms; those in the cognitive, somatic, and emotional domains, as well as physical signs, behavioural changes, and cognitive impairment. The majority of concussions resolve in a 7-10 day period (P. McCrory et al., 2013), however, a significant minority of mTBI patients continue to experience symptoms for months post-injury. These rates vary from 7-33%, however, cognitive deficits can remain for more than 1 year post-injury (Vanderploeg, Curtiss, & Belanger, 2005). These patients are suffering from Post-Concussion Syndrome (PCS), and the lingering symptoms are often accompanied by depression or anxiety, which can enhance the original symptoms and lead to an ongoing cycle of symptomology (Mittenberg & Strauman, 2000). Recent studies suggest that the overall burden of PCS, which includes presence of post-concussive headache, or a reported history of previous concussions, may correlate with time to recovery (Makdissi et al., 2010), even though cognitive function in patients with mTBI measured at 3 months post-injury are no different from healthy controls, those subjective PCS complaints can linger (Chen et al., 2003). While included in the DSM-IV, little evidence from physical examination and imaging is seen in these patients, and the diagnosis is mostly based on reports from the patient and family members (Chen et al., 2003), however, sufferers of PCS have been found to experience cognitive failures in everyday life, and have poor performance on neuropsychological testing (Sterr, Herron, Hayward, & Montaldi, 2006). Diagnosis of PCS is difficult and has led to controversy as to whether the syndrome is a psychological or organic phenomenon (Duff, 2004). As such, rehabilitation methods for PCS are also controversial; with cognitive rehabilitation, attention-enhancement programs, psychological therapy, and neurotherapy all receiving mixed results in the literature, and no standard treatment method found to be effective for management of PCS (Duff, 2004). Patients who suffer from PCS may experience self-reported decreased

quality of life, ongoing symptoms and cognitive impairment which affects all aspects of their lives.

For athletes who suffer repeated concussions to the head or multiple subconcussive blows over the course of their career, the discovery of chronic traumatic encephalopathy (CTE) as a potential consequence of concussion has become a troubling possible result. Only diagnosed with an autopsy, CTE can present with cognitive, behavioural, and/or motor symptomology (Jordan, 2015); evidence of chronic neurodegeneration. First described by Dr. Martland in 1928 as 'dementia pugilistica', the "punch drunk" state of boxers was the basis for the description of the disease. The most common symptoms reported with CTE are depression, agitation, paranoia, and depression, with signs such as gait disorders, and slowing speech often described (Gardner & Perry, 2014). CTE is a progressive taupathy characterized by the presence of tau proteins in various regions of the brain, and patients may be mistaken as suffering from Alzheimer's disease or dementia (McKee et al., 2013). The high morbidity and mortality rates for those with CTE are only now being seen; with media reports, research, and education starting to focus on the seriousness and long-term effects of concussion. Unfortunately, how much head trauma is causative, the frequency of trauma, genetic predisposition, and age are not yet known, so athletes who suffer concussions during their careers cannot be certain of the long-term outcomes of their injuries.

A final catastrophic consequence of improperly managed concussion is second impact syndrome (SIS), which has been defined as when "an athlete who has sustained an initial head injury, sustains a second head injury before symptoms associated with the first have fully cleared" (P. R. McCrory & Berkovic, 1998). Even with a relatively mild secondary impact, the brain is more vulnerable as a result of the initial impact and its ability to self-regulate the amount of blood volume to the brain is damaged, leading to uncontrolled brain swelling and brain herniation, often resulting in death within minutes (Bey & Ostick, 2009). Second impact syndrome is exceedingly rare, however, with a

100% morbidity rate and a 50% mortality rate (Cantu, 1998), prevention is the only way to effectively manage the injury. Recent research has debated the existence of SIS (McLendon, Kralik, Grayson, & Golomb, 2016), however, the cases of death and disability following head injury are undeniable. Further, decreased reaction times and impaired speed of information processing are documented results of concussion, therefore, even in the absence of the catastrophic consequences of chronic neurological deficits or second impact syndrome, athletes who return to play while still symptomatic are at an increased risk of other injuries (P. McCrory, Davis, & Makdissi, 2012).

Looking ahead to future research into reporting of concussive symptoms and mechanisms, specifically why athletes choose to hide symptoms from medical staff, it is important that tests used to assess concussions are accurately determining when an athlete is, in fact, concussed and trying to hide it, and conversely, when an athlete is not concussed but exhibiting concussion-like symptoms or neurocognitive deficits. When utilizing self-reporting scales, there must be an opportunity for an athlete to identify current injury, illness or fatigue, as well as previous history of concussion, in order to ensure that baseline scores are not inflated. Also, weaknesses in computer-based methods of neurocognitive testing need to be acknowledged so that issues with validity and reliability can be addressed. Currently the “best practice” approach of physical and cognitive rest for athletes suffering the symptoms or cognitive deficits of a concussion make it difficult for medical practitioners to convince an athlete to honestly report symptoms when he or she knows that any red flags will cause them to be pulled from sport. Clinical testing needs to be objective and accurate enough to be able to identify those athletes who are not honestly reporting their condition, while ensuring that athletes are not being held back with symptoms that are in fact not due to a concussion.

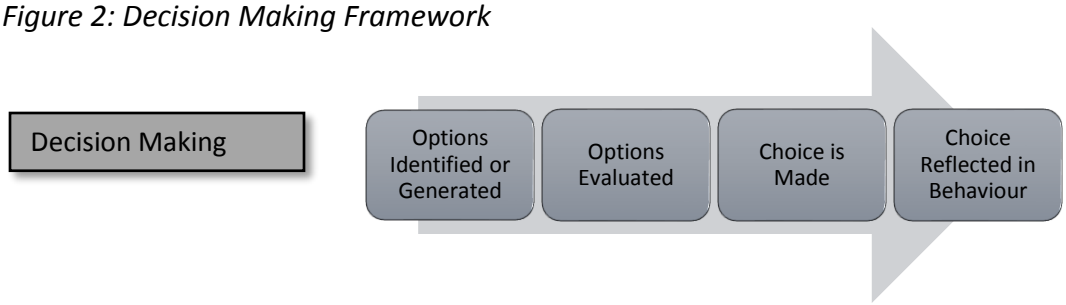
Unfortunately, most concussion assessments rely on self-reported symptoms, and athletes for many reasons may not report their symptoms to coaches or medical staff, which may result in athletes returning to play too early. This may lead to increased risk of re-injury, or potentially catastrophic consequences like Second Impact Syndrome.

These adverse outcomes are more frequent when concussions are not identified and athletes are allowed to continue playing, or when athletes identified with a concussion are allowed to return too early, before they have fully recovered. Research by Covassin et.al. found that an athlete who has suffered a concussion has a 3-times greater risk of suffering another one in the same season (Covassin, Schatz, & Swanik, 2007). While on-field assessment tools like the SCAT3 and BESS make objective concussion assessment easier, most tools rely on subjective symptom reporting by athletes as a basis for determining return to play status. Many athletes are highly motivated to continue playing even while injured, whether it be a musculoskeletal or brain injury, and often choose to do so at the detriment of their long-term health. While anecdotally one could recognize an athlete's desire to lie and hide symptoms in order to continue playing, there are questions as to whether an athlete is cognitively able to make sound decisions after mild traumatic brain injury, based on the anatomy of the decision making centres of the brain, consent to treatment parameters, and awareness of their own deficits in brain injured subjects, particularly if decision making capacity is impacted by the concussion.

Decision Making

Decision making is a cognitive process, or set of processes that an individual undergoes in order to determine a course of action, which involves a synthesis of a variety of kinds of information. Multimodal sensory inputs, autonomic and emotional responses, past associations, and future goals are all crucial inputs that go in to the decision making process (Fellows, 2004). An individual must be able to synthesize incoming, new information with previous experience and knowledge in order to reach an appropriate course of action. The new inputs are also integrated with information about uncertainty, timing, a cost-benefit analysis, and risk and then the appropriate action is decided upon. In 2004, Fellows and colleagues developed a framework for decision making that follows these general steps:

Figure 2: Decision Making Framework



Adapted from Fellows (2004)

Decision making areas of the brain are located in the prefrontal cortex, especially the ventromedial prefrontal cortex (VMF). This area includes the medial portion of the orbitofrontal cortex and the ventral portion of the medial wall of the frontal lobes, and is responsible for abstract thinking and thought analysis – critical requirements to be able to make sound decisions. The prefrontal cortex allows one to focus his or her thoughts, pay attention, learn, and concentrate on goals as well as its responsibility for the processes involved in decision making and social control. The ventromedial prefrontal and caudal orbitofrontal regions are classified as the paralimbic cortex, and are closely connected to the limbic structures of the amygdala and hypothalamus, to provide descending input into the midbrain. In particular, the amygdala plays a very important role in decision making, possibly through its interconnections with the orbitofrontal cortex. The amygdala is responsible for the encoding, storage and retrieval of episodic, autobiographic memory, and motivationally significant stimuli. The orbitofrontal cortex (often synonymous with the ventromedial prefrontal cortex), is responsible for the cognitive processing of decision making, and works with the amygdala and other limbic structures to integrate the emotional and reward aspects of decision making, described as the "pleasure obtained from solving problems" (Fellows, 2004)

Lesions in humans that involve the ventromedial frontal lobe are often studied when looking at decision making and that region is often injured through aneurysm rupture, surgical removal of tumours, and traumatic brain injury. Clinicians have reported impaired decision making in patients with VMF damage, often noting impairments in the

emotional aspect of decision making. These patients with lesions in the VMF develop severe impairments in personal and social decision making in spite of mostly preserved intellectual abilities (Bechara, Tranel, & Damasio, 2000). Further, there is no evidence that VMF damage affects the evaluative aspect of decision making; instead, lesions or damage to the ventromedial sector of the prefrontal cortex interfere with the normal processing of "somatic" or emotional signals, while sparing the most basic cognitive functions. Such damage leads to impairments in decision making in real-life because the evaluative aspect is not affected- individuals can still understand the choices offered and choose between options, but there is no consideration of long-term consequences. Patients with VMF injuries are often described as impulsive, however, clinical studies have shown that they in fact spend too long contemplating options while attempting to make decisions, leading Bechara et.al. to question whether these patients are impaired in applying stopping rules (Bechara, 2004). He found that patients with VMF damage have difficulty with open-ended, unstructured task environments, which led to the conclusion that a link exists between abnormalities in emotion and feeling in patients with VMF damage and their severe impairment in judgement and decision making in real life. This work by Bechara echoes a previous study by Tranel, who found that patients with VMF lesions make bad decisions in real life and in lab tasks, and have impaired feelings and emotions (Tranel, Bechara, & Denburg, 2002).

Interestingly, when investigating combat-related Post-Traumatic Stress Disorder (PTSD), it was found that the anterior limbic-related areas are implicated in the condition; including regions like the medial prefrontal, anterior cingulate and orbitofrontal cortices, amygdala, and others (Taber & Hurley, 2009). PTSD can develop even when the person has no memory of the traumatic event, in fact, 9% of military personnel who had not been injured during active duty screened positive for PTSD, whereas 16% of those with bodily injuries were found to have PTSD (Hoge et al., 2008). Cognitive activation studies undertaken on military personnel by Taber and Hurley (2009) indicated increased amygdalar and decreased prefrontal cortical response to a threat, and that a higher lesion burden in the orbitofrontal cortex is associated with lower rates of PTSD.

They also found that a higher lesion burden in the temporal lobes is associated with a higher likelihood of developing PTSD, but that injury to the VMF and anterior temporal cortex associated with a lower probability of developing PTSD. This is interesting because there is a large overlap in symptoms between mTBI (specifically concussion) and PTSD, including depression, personality changes, impulsivity, and aggression. To this point, however, there is no clinical method to distinguish which condition is responsible for symptoms that cross both domains.

The functions of the prefrontal cortex may not fully develop until the age of 25 (Bechara, 2004), which means that the development of neural connections that are the basis for complex behaviours like decision making and control over powerful temptation is still taking place during the collegiate years. This has huge implications for collegiate varsity athletes who suffer brain injury either before or during their university sports career. If athletes are asked to make choices regarding their return to play status, and make healthy, safe choices about their injury, can a brain that is not fully developed, (and has possible injury to the key structures in decision making) make sound decisions? Research has found that common areas for injury in mTBI include the frontal lobes and orbitofrontal cortex (Messé et al., 2011; Metting et al., 2009; Sasaki et al., 2014; Slobounov et al., 2010), areas critical for the decision making process. College-age people are often described as impulsive and making poor choices in social situations, which may be a result of their immature brains; this, combined with trauma-induced changes to those same areas of the brain through sport participation, may in fact result in even more impaired decision making abilities in these same individuals.

Iowa Gambling Task

One method of evaluating decision making is the Iowa Gambling Task (IGT), a computer-based assessment tool which can assess a subject's ability to differentiate between immediate reward with long-term loss, and small immediate rewards with overall long-term gain. By using 4 virtual decks of cards, subjects are told that each time they choose a card they will win money – the objective of the task is to win as much money as

possible after 100 turns (where 1 card-flip is 1 turn), however, every so often they will lose money. Two of the decks will lead to a net gain of money, while the other 2 decks will lead to a net loss of money. Using this tool, many studies have investigated decision making in brain-injured subjects. As previously mentioned, Bechara and colleagues looked at patients with VMF damage, and using the IGT found that working memory is not dependant on the intactness of decision making, however, decision making seems to be influenced by the intactness or impairment of working memory. His study found that patients with VMF damage didn't seem to be able to decide advantageously in immediate versus delayed reward/punishment decisions, as evidenced by lower amount of money accumulated during the IGT, and the fact that VMF patients didn't avoid the bad decks, in fact they preferred them (Bechara, 2004). These results support the idea that decision making is guided by emotional or somatic states which are generated in anticipation of future events. The authors argue that impulsiveness, or lack of response inhibition, is different from decision making – both cognitively and anatomically. Deficits in decision making may be described as a type of cognitive impulsiveness, or a failure to delay gratification and evaluate the outcome of a planned action. These findings support previous research by Tranel (2002) who looked at the contribution of the left and right side of the VMF in regards to social conduct, decision making and emotional processing. Using patients with stable, focal lesions to either the right or left VMF, he utilized the IGT to investigate decision making, as well as other tests to examine social conduct, emotional processing and personality. Tranel's results showed that subjects with right-sided lesions had frequent and profound disturbances in social conduct, severe problems in interpersonal functioning and social status, and poor performance on the IGT. The IGT results showed that patients with a unilateral right-side lesion to the VMF continuously performed in a disadvantageous direction, however, it was not as pronounced as those with bilateral lesions (as shown in previous studies). These findings illustrate that the right VMF makes huge contributions to functions like social conduct, decision making and emotional processing, and that it is important for processing the emotional significance of stimuli (Tranel et al., 2002).

Optimal performance on the IGT has been linked to the development of appropriate emotional signals of reward and punishment that could be masked by pain. High self-reported pain levels in those with chronic low back pain and headaches also affect the function of the critical decision making sectors of the brain that utilize emotional signals to determine the appropriate course of action when confronted with two or more choices. (Verdejo-García, López-Torrecillas, Calandre, Delgado-Rodríguez, & Bechara, 2009). In relation to someone suffering the pain and disability associated with (either short or long term), who is expected to make choices based on emotion (like wanting to play or intrinsic or extrinsic pressure to complete tasks), it leads to the question of whether these people are in fact impaired in their ability to make advantageous, healthy and safe choices because those processes are affected by the underlying pain signals disrupting function of the CNS.

Capacity to Consent to Treatment

The previous section discussed how traumatic brain injury can affect an individual's ability to make sound decisions based on injuries to critical structures like the VMF and certain limbic structures. While it is understood that damage to these areas can lead to serious impairment in decision making capacity, when dealing with athletes and patients in a real-world or clinical setting, medical practitioners don't often have access to tools like fMRI and the Iowa Gambling Task to objectively conclude that decision making has been negatively affected. This, coupled with the fact that medical personnel dealing with collegiate-level athletes are working with individuals with decision making structures that are not fully developed, means that those tasked with determining return to play status after concussion may not be able to make correct decisions when utilizing the subjective and objective testing currently available to them. To add to the dilemma is the concept of consent to treatment – namely the ability of a participant to voluntarily consent to research or treatment, using free choice, adequate understanding and the capacity to give consent (Appelbaum, 2007). Capacity also includes the resources that a patient can rely on to provide informed consent.

This concept is interesting in the case of mTBI and concussed collegiate-level athletes in particular because it entails working with patients who quite possibly have impaired decision making and now they are expected to make sound choices when it comes to school, social interactions, athletics and activities of daily living. The legal standards for competency are rigorous and encompass the following requirements:

1. Evidence of choice
2. Factual understanding of the issues – which combines the ability to understand and actual understanding
3. Rational manipulation of information
4. Appreciation of the nature of the situation – i.e. patients can relate factual understanding to their own situation

Adapted from Sturman (2005)

A determination of competency, and thus the ability to give consent, must take into account the decision making capacity demands placed on the patient, which include different situational and social factors, as well as the consequences of a judgement (Sturman, 2005). While there are many tools available to practitioners to assess competency in severely brain injured individuals, as well as those with dementia and other mental health disorders, unfortunately very few are transferrable for use with mTBI patients, especially those with concussion.

Capacity to Consent to Treatment Instrument

One instrument often used on patients with varying severity of brain injury is the Capacity to Consent to Treatment Instrument (CCTI), which utilizes two clinical vignettes that present hypothetical medical problems and symptoms, as well as two treatment alternatives with associated risks and benefits. Participants are required to consider the medical problem, its symptoms, the diagnosis, and the risks and benefits of the different treatment options presented. This tool assesses five core consent standards which are described below:

- S1 – Expressing treatment choice (Expressing Choice)
- S3 – Appreciating personal consequences of a treatment choice (Appreciation)
- S4 – Rational reasons for a treatment choice (Reasoning)
- S5 - Understanding the treatment situation, available treatment choices, and respective risks/benefits (Understanding)
- S2 – Ability to make "reasonable" treatment choices – not a clinically acceptable standard

Adapted from Triebel et al. (2012)

Consent standards S1 and S2 are basic standards; in fact, S2 is not clinically acceptable because of the vague definition of "reasonable". On the other hand, standards S3-S5 are increasingly complex and gradually incorporate higher executive functioning and reasoning skills to reach the final stage (S5) which is the most complex and clinically relevant consent ability.

Medical Decision Making

Capacity to consent is a very important concept when dealing with subjects in the laboratory and from a legal perspective. However, in a clinical setting medical practitioners must ensure that their patients have appropriate medical decision making capacity; specifically the mental and emotional capacity to consent to, or refuse, a certain medical intervention (Okonkwo et al., 2008). Patients with traumatic brain injuries (TBI) often experience impaired decision making ability at the time of injury, and as such, are not sound to give medical consent to their treatment. While this may be obvious for an individual with prolonged loss of consciousness (LOC) or traumatic amnesia after brain injury, someone with mTBI in the form of concussion may appear able to make sound and rational medical decisions, however, they may in fact be missing the critical aspect of understanding their injury.

Impaired medical decision making capacity can sometimes last into rehabilitation and long after the brain injury has "healed". In fact, Marson et al found that at the time of acute brain injury in those with moderate to severe TBI, the complex consent abilities of

appreciation, reasoning and understanding were significantly impaired, even as long as 6 months post-injury (Marson et al., 2005). This was especially evident for appreciation and understanding abilities, while the simple consent standards of evidencing a choice and making a reasonable choice remained largely intact. Similarly, when neurocognitive predictors associated with medical decision making capacity were examined in patients with moderate to severe TBI, Dreer and colleagues found that at 6-month follow-up TBI patients had significant improvement in S3, S4 and S5, however, they continued to perform significantly below controls on the S3 and S5 domains of the core consent standards (Dreer, DeVivo, Novack, Krzywanski, & Marson, 2008). In fact, after 6 months TBI patients continued to perform below controls on almost all cognitive variables that were tested (CCTI, orientation, attention/concentration, visuospatial skills, processing speed, memory, fine motor functioning, and executive function), except for visual recall, visual discrimination, concept formation and mental flexibility. While it is important for the TBI patients that they had improvement in all areas that were tested after 6 months, they had not improved to levels close to healthy controls – illustrating the deficiencies in decision making and understanding that these patients were still experiencing. The study by Dreer and colleagues illustrates that short-term verbal memory is strongly associated with impairments in consent capacity in short-term, acute stages of brain injury; however at 6-month follow-up it was basic language comprehension, executive function and working memory that were most strongly associated with capacity performance. Once again, it is the most complex consent standard of understanding (S5) that it is most likely to show impairment with brain injury, and is summed up by Dreer the following way:

> "Before a person with a head injury can begin to reason, demonstrate mental flexibility in thinking about medical options and integrate the information, he or she has to have the basic abilities to encode, retain and recall new information about his or her medical situation"
>
> Dreer, 2008 p.495

The final consent standard (S5) on the CCTI is highly memory intensive and requires encoding and consolidation of new medical information in order to obtain full

understanding of one's condition, the treatment options available and the risks and benefits of the treatment options. Many studies have been done on moderately to severely brain injured patients in order to understand the effect brain injury has on capacity to consent, and how changes occur over time. Very little literature is available on mTBI patients, but practitioners must be aware of the deficits that could exist in the patient's reasoning, encoding, integration and retention of information capacity, even in those with "mild" concussion. If any of these parameters are impaired, a patient cannot demonstrate the requisite understanding and therefore have the capacity to consent to medical treatment.

One of the few studies to look at mTBI patients and medical decision making compared mild, complex-mild (cm) and moderate-severe (msev) TBI patients with a battery of neuropsychological tests, including the CCTI, was undertaken by Triebel in 2012. The only difference between mild and complex-mild participants in this study was the existence of structural brain changes evident on neuroimaging studies in the complex-mild patients. Triebel found that controls and mTBI subjects did not differ on any consent standard, however, cmTBI participants performed below controls on understanding (S5). Significantly, the mTBI and cmTBI groups did not differ statistically on any consent standard, but the cmTBI raw scores fell below the mTBI scores on all 3 complex standards (appreciation, reasoning and understanding). One-month after injury, medical decision making capacity was largely intact for mTBI subjects, however was still significantly impaired for cmTBI and msevTBI participants. For mTBI subjects, a category of brain injury that most concussed athletes would fit, approximately 30% demonstrated an impaired capacity to consent on appreciation and 20% were impaired on the understanding standard (Triebel et al., 2012). This indicates that nearly ⅓ of the subjects in this study with mTBI had compromised capacity, which demonstrates that medical decision making capacity, even in TBI patients with normal neuroimaging, must be considered and evaluated. This study is consistent with other studies that have shown longer recovery rates and worse outcomes in patients with cmTBI compared to "uncomplicated" TBIs, however, the small sample sizes may have caused the cmTBI and

mTBI scores to show little group difference (Triebel et al., 2012). For the purpose of this paper, however, it should be noted that with the improved neuroimaging studies on concussed athletes that are showing brain lesions even with little cognitive impairment, perhaps the group differences are not significant because in fact those put into the mTBI cohort would have shown lesions with more advanced neuroimaging data. This would move those subjects into the cmTBI group which demonstrated impaired decision making capacity, illustrated by some level of impairment on the 3 complex standards.

One of the reasons why mTBI patients, and concussed patients more specifically, are not easily assessed for decision making capacity is the heterogeneous nature of that group. While the majority of concussed athletes recover within 7-10 days, a large minority still exhibit cognitive impairments more than 1 month post-injury, making this group extremely diverse and hard to assess with consistent findings.

Self-Awareness

To this point, it has been assumed that athletes could be lying about their symptoms in order to return to play even while still experiencing effects of the concussion, or, perhaps they don't have the capacity to understand their injury and potential risks or consequences when asked to make medical decisions. However, research has not yet been able to determine if in fact there are deficits in decision making or if athletes are lying to hide the effects of the concussion. Perhaps athletes simply aren't aware of their own deficits and are therefore not able to relate them to medical personnel.

Self-awareness is considered a process which involves the integration of information from both external reality and inner experience, which is created through a widely distributed neural network. As "the capacity to perceive the 'self' in relatively objective terms whilst maintaining a sense of subjectivity" (G. P. Prigatano & Schacter, 1991), self-awareness includes both cortical and sub-cortical components and requires activation, feedback, and central processing of information (Sherer, Hart, Whyte, Nick, & Yablon, 2005). Therefore, self-awareness involves the interaction between thoughts (knowledge

of a situation in an objective sense) and feelings (or an appreciation or unique interpretation of the situation in a subjective sense).

Three levels of processing are thought to influence the accuracy of self-reporting:

1. Awareness – The ability to attend, encode, and retrieve information concerning oneself
2. Appraisal – The current information about oneself is compared to longstanding (pre-injury) self-evaluation
3. Disclosure – The willingness to report self-perceptions to others in an accurate and honest manner

Adapted from Allen and Ruff (1990)

The first level is self-awareness of the injury-related deficits themselves; that is the particular physical, cognitive, social and emotional deficits apparent post-injury. This aspect equates with the objective awareness or `knowledge of' deficits. Self-awareness of some deficits, particularly physical disabilities, is often achieved more readily than self-awareness of social and emotional competence (G. Prigatano & Altman, 1990). Secondly, self-awareness extends to awareness of the functional implications of deficits based on pre-injury standards for social interaction, athletics and activities of daily living. This second aspect is highly subjective and unique between individuals and his or her interpretation of deficits. The third aspect of self-awareness, which requires the patient to willingly disclose those perceptions to others can be exceptionally difficult for athletes who are highly motivated to return to play, as well, who have grown up with the athlete ethos of playing through pain and injury.

Neuroanatomical studies of self-awareness are limited, especially on subjects with mTBI, however, it is thought that the frontal lobes and right hemisphere contribute to self-awareness, but studies are not conclusive (Sherer et al., 1998). The relationship between injury severity, awareness of deficits and emotional adjustment have not been explored extensively in mTBI patients, yet it is known that impaired awareness is

frequently found after acquired brain injury – and studies on severe TBI patients have borne this out. Allen and Ruff found that inaccurate self-reporting in severely brain injured subjects may be a result of deficits in self-awareness due to impairments in attention, memory and logical thinking (Allen & Ruff, 1990).

Clinical experience suggests that impaired awareness may be related to patients' general cognitive and emotional functioning, however, studies to this point have not definitively demonstrated this (Sherer et al., 1998). To this end, research performed by Sawchyn found that self-awareness is more impaired for cognitive and/or socio-emotional aspects of functioning, as opposed to activities of daily living (Sawchyn, Mateer, & Suffield, 2005). This makes sense for mTBI patients as well, who can often perform their normal activities of daily living, while they are seen to be making questionable choices on more complex tasks. Anecdotally one can relate this to concussed athletes as well – many on-field medical personnel have related stories of concussed athletes able to perform the rudimentary skills of their sport (those practiced thousands of times during practice), however, those same athletes cannot run newer plays when called upon to do so, or are even seen walking to the wrong bench or huddle between plays. When asked, those same athletes do not report symptoms to the medical staff, nor are they aware of their inability to perform the requirements of their sport.

While anecdotal evidence may be used by front-line medical personnel as part of the "tool-box" used in the art of sideline concussion assessment, objective, empirical testing needs to be performed in order to assess a brain-injured patient's self-awareness, and therefore his or her capacity to make decisions. Unfortunately all rating tools to determine self-awareness have their limitations, and little is known about the comparability of methods. Often, two tools are used – one for the patient (a self-rating scale) which is compared to the evaluation of a family member, clinician, or to the patient's own performance on objective measures of cognitive function. There is also direct clinician rating of a patient's accuracy of their self-appraisal. In studies assessing

brain-injured patients' self-awareness, patients tend to show better awareness of physical deficits than cognitive and behavioural ones. Impaired self-awareness is most pronounced in profound neurologic deficits (i.e. stroke patients), but can also be seen in those with head trauma. It can interfere with rehabilitation and result in poorer functional outcomes (Sawchyn et al., 2005). Interestingly, when Sawchyn and colleagues used patient competency rating scales (to evaluate patient competency on cognitive, behavioural and emotional activities) and compared those ratings to scales completed by "significant others" close to the patients, those with mTBI demonstrated an underestimation of their abilities (Sawchyn et al., 2005). As previously noted, this is an often under-studied group as they reflect a high amount of heterogeneity, and the patients in this study had been referred to a rehabilitation centre, so they were experiencing ongoing issues related to their brain injury, which is not commonly found in mTBI patients. What this study suggests, however, is a response style by mTBI patients that exaggerates deficits, and ratings by significant others that showed helplessness, confusion and bizarre behaviour in those mTBI patients. This is in contrast to findings of those with severe TBI who have been found to overestimate their performance on neuropsychology tests (Allen & Ruff, 1990). Overall, mild and moderate TBI patients are known for verbalizing their post-concussion symptoms whereas those with severe brain injury generally underestimate their deficits and are unwilling (or unable) to effectively report their self-perceptions. This however may not be the case for athletes, especially those who have been engaged in their sport for a long period of time, as those individuals may have an overarching drive to continue their sport, even while experiencing symptoms of a concussion.

Multiple brain areas are involved in self-awareness, but the frontal lobes are of particular importance. Many areas are involved with introspection, yet studies indicate that the medial frontal lobe areas are activated during self-reflection. A study by Sherer et.al. in 2005 found that the left orbitofrontal cortex, medial frontal lobe, posterior parietal lobe, and right frontal lobe were active during tasks requiring self-awareness (Sherer et al., 2005). When investigating patients with lesions in the right hemisphere,

Ranseen et al found that these TBI patients rated themselves as functioning better than their clinicians rated them (Ranseen, Bohaska, & Schmitt, 1990). This finding was in contrast to those of Prigitano and Altman (1990) who found that there was no difference between hemispheres, however, patients with more intracranial lesions showed more impaired self-awareness (G. Prigatano & Altman, 1990). These results were replicated by Sherer and colleagues in 2005, and are very interesting when one considers the increased number of lesions now visible with advanced neuroimaging procedures.

When investigating the role of decision making and self-awareness in concussed athletes, there are unfortunately few studies to draw from. Most studies are performed on patients with moderate to severe brain injury, as these are subjects with more obvious and profound deficits, and may encompass a much more homogenous group that the huge variety of patients who make up the mTBI cohort. One consistent theme between self-awareness and decision making is the importance of specific areas of the frontal lobe, prefrontal cortex and right hemisphere in particular. Located just behind the forehead, these areas are highly susceptible to injury during sport participation and can be implicated in deficits in emotional aspects of decision making as well as understanding of one's injury and the potential consequences of certain treatment options (i.e. no treatment and early return to play). One of the few studies looking specifically at mTBI patients was that of Triebel, who found that ⅓ of subjects with mTBI had decreased capacity to consent, but had normal neuroimaging. While advanced neuroimaging techniques like Blood Oxygen-Level Dependent fMRI and DTI are not readily available to physicians who see the majority of concussed collegiate athletes, as studies increasingly report lesions in brains of those athletes previously thought to have no intracranial lesions, concussion treatment will inevitably reflect these findings (Triebel et al., 2012).

The relationship between increased numbers of intracranial lesions and impaired self-awareness relates directly to a concussed athlete's ability to make informed decisions

and consent to their treatment. Without self-awareness, one cannot meet the informed consent criteria of understanding and appreciation of their injury, therefore the individual cannot be allowed to make medical decisions which could potentially affect their long-term health. Since adverse outcomes are more frequent when concussions are not identified, athletes are allowed to continue playing when concussed, or when athletes are identified with a concussion are allowed to return to play before they have fully recovered, and most concussion assessment relies of self-reported symptoms (Fazio et al., 2007), athletes are placed in exceptionally risky situations if they do not possess the requisite capacity to verbalize their symptoms or understand the consequence of returning to play.

In a 2013 study, Torres and colleagues found that 43% of collegiate athletes at a large Division 1 American university with a history of concussion had knowingly hidden symptoms to stay in a game, and 22% of athletes overall reported that they would be unlikely or very unlikely to report symptoms to a coach or trainer (Torres et al., 2013). In fact, those with a history of concussion were less likely to anticipate reporting future concussions to staff than those without a history of concussion. While these numbers are cause for concern, research has yet to focus on whether these athletes are in fact capable of making decisions and self-aware enough while concussed to draw such conclusions.

It is beyond the scope of this paper to quantitatively examine decision making capacity among collegiate athletes with concussion; however, the immaturity of the decision-making areas of the brain, as well as the potential for damage to the decision-making and areas of the brain responsible for self-awareness in those with concussion must be recognized when managing collegiate-level athletes with head injuries. Therefore it is relevant to this research that impaired self-awareness and capacity to formulate rational and medically sound decisions is an important component when investigating reporting intention and behaviour in the collegiate age athlete.

Sport Characteristics

The numbers of sport-related concussion in the United States are varied, ranging from 300,000 to 4 million per year (Colvin et al., 2009; Covassin et al., 2007; McGannon, Cunningham, & Schinke, 2013), however, it is widely believed that these numbers are underestimated due to lack of reporting by athletes (Barnes et al., 1998; Boden, Kirkendall, & Garrett, 1998). Traumatic brain injury resulting from sport participation occurs most frequently in people aged 5-24, and while 90% of these injuries are considered mild (Kaut, DePompei, Kerr, & Congeni, 2003), if the incidence of underreporting is as high as some researchers estimate (up to 62%) (Broglio et al., 2010; Kroshus, Baugh, Daneshvar, Nowinski, & Cantu, 2014; Michael McCrea, Hammeke, Olsen, Leo, & Guskiewicz, 2004; J. K. Register-Mihalik et al., 2013; Torres et al., 2013), the potential public health issue created by improper management of these athletes is very serious. Among individuals aged 15-24, sports are the second leading cause of concussion behind motor vehicle accidents (Marar, McIlvain, Fields, & Comstock, 2012), and as sport participation in youth increases, the numbers of sport-related concussion can be expected to rise as well.

Collision sports like hockey and football provide obvious mechanisms for concussion in almost every play. However, in many studies of collegiate and high school athletes, soccer players had an extremely high incidence of concussion, despite the fact that it is not considered a collision sport (Tracey Covassin, C Buz Swanik, & Michael L Sachs, 2003a, 2003b; J. S. Delaney, Lacroix, Leclerc, & Johnston, 2002). Soccer is arguably the most popular sport in the world, with over 240 million amateur players and 200,000 professional players (Colvin et al., 2009). It is unique among most sports in that both males and females play the game exactly the same way; with no alterations to equipment or rules between the sexes. Research on the incidence of concussion in soccer varies greatly; with estimates of concussion ranging from 2-7% of all soccer injuries (Barnes et al., 1998; Sandelin, Santavirta, & Kiviluoto, 1985). With over 240 million registered players, this adds up to more than 1.68 million potential concussions

worldwide in the sport of soccer alone. There are also a number of potential mechanisms for concussion in soccer – head to head contact, head to ball contact ("heading"), head to other body part and head to ground contact. While heading the ball is not considered a risk factor for concussion (Colvin et al., 2009), players often come in physical contact with one another during the act of heading the ball, and even without direct contact to the head, forces can be transmitted through the body or neck which may cause a concussive injury. Barnes and colleagues found 52% of elite male soccer players had suffered at least one concussion, and estimated that males had a 50% probability of sustaining a concussion over the course of their career (Barnes et al., 1998). Research by Delaney on Canadian university soccer players indicated that 62.7% of soccer players experienced symptoms of a concussion during the year of the study, with 46.2% of them experiencing those symptoms during the fall season alone (J. S. Delaney et al., 2002). Soccer players, while not involved in direct collisions like in football, hockey or rugby, still have many instances of body and head contact which could be mechanisms for concussion. In particular, soccer games appear to provide a much greater risk for concussions than practices. According to Covassin et al, male soccer players are at a 21.9 times greater risk of concussion during a game than practice, and females a 16.7 times greater risk (Tracey Covassin et al., 2003b) and incidental contact involved with heading the ball, as well as contact with other players and the ground are the main causes of concussion (Marar et al., 2012). It is also interesting to note that at the collegiate level, it is unlikely for a Certified Athletic Trainer/Therapist is available to cover soccer games and practices (as opposed to collision sports), which means that soccer concussions may not be as well captured as those of hockey and football (Rivara et al., 2014).

Unlike soccer, hockey has different rules in place for the men's and women's games. Men's hockey is considered a collision sport, in which directed, forceful hitting is trained for, and expected during game play. The women's rules, on the other hand, penalize body checking and hard hits into the boards and is considered to be a contact sport. However, there is a significant amount of body to body contact in the women's game, as

well as falls to the ice and contact with the boards that can result in physical injury. With a hard playing surface surrounded by rigid boards, and players traveling at speeds over 40kph (Wilcox et al., 2014), and contact (either purposeful or incidental), the incidence of concussion in hockey is high, and both men and women experience high concussion rates, despite the rule differences in the sport. In a 3 year study of collegiate ice hockey players, female players were found to have an average of 10.4% of all injuries be concussions, while 6.1% of all injuries were concussions in male players (Tracey Covassin et al., 2003b). The same study also found that ice hockey players were at a 15.5 times higher risk for experiencing a concussion during game play than during practice. Recent research into the biomechanics of head impacts in ice hockey found that the total number of head impacts received by an individual male player in a single hockey season was a median of 287, significantly higher than the female median of 170 (Wilcox et al., 2014). Interestingly, the same study found no statistically significant differences in the frequency of impacts to different locations on the helmet between males and females, however, males experienced blows that caused higher acceleration magnitudes than females (Wilcox et al., 2013). Therefore, males are experiencing both a greater number of hits to the head, as well as a greater magnitude of force than their female counterparts. Player to player contact has been found to be the most common mechanism for concussions in university-level players, accounting for 72% of diagnosed concussions in male players, and 41% in female players (Wilcox et al., 2014).

Like ice hockey, rule differences between men's and women's field lacrosse often make it appear like a different game altogether. While men wear helmets, gloves, and shoulder pads, and are allowed contact during game play, women's field lacrosse players do not wear protective padding (except the goalie), and contact between players and sticks to players is penalized. However, research regarding concussions in women's lacrosse has found that the largest percentage of concussions are caused by player-equipment contact; for example, a stick hitting a player in the head (Marar et al., 2012). Men's lacrosse allows body contact, which leads to collision with an opponent being the number one cause for concussion, whereas head-object contact accounts for

up to 50% of concussions in women's lacrosse (Marshall, Guskiewicz, Shankar, McCrea, & Cantu, 2015). Like hockey and soccer, the majority of concussions in lacrosse occur in games, with studies finding that concussions accounted for between 13.9% and 21.2% of all injuries sustained in games (Tracey Covassin et al., 2003a; Marar et al., 2012). Further, women's lacrosse players have been found to experience fewer injuries that female athletes in other sports; however, the percentage of concussions in lacrosse is higher than other women's sports (Tracey Covassin et al., 2003a).

Research has found that the most common mechanism for concussion in soccer and hockey was being hit in the head, with the side/temporal area of the head being the most probable area to be struck in soccer. Contact with an opponent, specifically another player's head was the most common mechanism for concussion in soccer, but it did not reach statistical significance (J Scott Delaney, Puni, & Rouah, 2006). Each of soccer, lacrosse and hockey are, at minimum, contact sports, with men's hockey considered a collision sport. While certain levels of contact are penalized in each sport, some contact is expected, and often desired in each of those sports. As noted previously, athletes in each sport suffer a higher percentage of concussions in game play than in practice, and with university seasons having anywhere from 15 (women's lacrosse) to 35 (men's hockey) games, there are many opportunities for concussions to occur.

It is beyond the scope of this paper to discuss sex-differences in concussion reporting and number of concussions experienced by male versus female athletes. However, it should be noted that there is debate about characteristics that may influence reporting, incidence and severity of concussions in women and men; physiological, psychological and social differences may influence both the incidence and reporting of concussions. However, in collegiate athletes, who must balance high-level game play and training with the stresses of school, concussion has been shown to have serious consequences on neurocognitive function and social interactions. Whether male or female, varsity athletes who suffer a concussion over the course of their season, which occurs

simultaneously with their academic year, may have increased challenges coping as a student athlete than their non-concussed peers.

Qualitative Research

It is estimated that between 50% and 75% of sports related concussions go unreported (Michael McCrea et al., 2004), however, little work has been done to date to establish reasons why athletes hide symptoms from teammates, coaches, and medical personnel. The reality for medical personnel who work with athletes on a daily basis is that concussion detection is not an exact science and often relies on the "art" of medical practice. While objective diagnostic tests and subjective reporting of symptoms are a key factor in proper detection and assessment of the concussed athlete, athletes will often actively attempt to hide or minimize symptoms in order to continue playing.

One of the most difficult issues to deal with in concussion assessment and management is the fact that concussions are an "invisible injury", which often means that athletes must approach medical personnel, coaching staff or teammates with complaints of symptoms in order for their injury to be detected. Chrisman et al. (Chrisman, Quitiquit, & Rivara, 2013) demonstrated that athletes are aware that concussions are dangerous, but that most would still play even though they are suffering symptoms. If this is in fact the case, the detection of concussion in athletes is an even more complex issue than simply the use of objective tests to quantify signs and symptoms. As discussed earlier in this paper, LOC was previously used to determine severity or even diagnosis of concussion, but current definitions of concussion specifically state that LOC is specifically not required for a concussion diagnosis (Cantu, 2001; Collins, Grindel, et al., 1999; Neurology, 1997). The fact that LOC or other obvious signs often do not occur with concussion, means that athletes can hide their injury and continue to practice or play, potentially putting themselves at risk for long term cognitive impairments, or catastrophic Second Impact Syndrome (SIS) (Cantu, 1998).

Concussion Education

Research into concussion assessment has focused on objective assessment tools and markers that can be used by clinicians and sideline personnel to detect concussed athletes and manage their care (Collins et al., 2003; Iverson, Gaetz, Lovell, & Collins, 2004; Iverson, Lovell, & Collins, 2003; Lau, Collins, & Lovell, 2011; Lau, Kontos, Collins, Mucha, & Lovell, 2011; Mark R Lovell et al., 2006; Maroon et al., 2000). While it is vitally important that concussions are detected early to prevent the previously mentioned consequences like cognitive deficits and SIS, and objective tools to aid in the assessment are key, it is becoming increasingly apparent that detection and assessment of concussion is multi-faceted and often relies on the skill of the therapist or physician at interviewing and testing the athlete, and also on the athlete to be honest about his or her symptoms. To this end, concussion education has become an integral part of athletic programs at both the high school and university level (Echlin et al., 2010; Kroshus, Daneshvar, Baugh, Nowinski, & Cantu, 2014), and the hope is that with increased awareness among parents, coaches, and athletes themselves, more concussions will be recognized and reported to medical staff. In 2003 Kaut and colleagues undertook a study to examine head injury knowledge in collegiate level athletes; results indicated that only 43% of the athletes in the study had “some” knowledge about concussions (Kaut et al., 2003). However, more recent research by Baker et al showed that 86% of Irish Rugby Union players believed that concussion was as serious as other injuries, and 75% believed that playing with a concussion could lead to long-term medical problems; yet one quarter reported playing rugby at some point whilst they were knowingly concussed (Baker, Devitt, Green, & McCarthy, 2013). This suggests that even with increased knowledge and awareness of the seriousness of concussion, athletes are still willingly hiding symptoms.

Further to this, a study on collegiate hockey players found that providing concussion education caused no overall increase in knowledge or intention to stop playing when

concussed (Kroshus, Daneshvar, et al., 2014). According to research by Bloodgood and colleagues, 84% of youth and 85% of parents had heard about concussion, and 70% of athletes thought concussion was a “critical issue” (Bloodgood et al., 2013). However, while 54% of athletes age 13-15 “strongly agreed” that concussion was a critical issue, only 34% of athletes age 16-18 strongly agreed. This study illustrates one of the critical issues involved in concussion education – namely that even with increased awareness of the seriousness of concussions and the signs and symptoms involved, athletes may still not disclose their injury. This was apparent in the previously mentioned study where older youths were more likely to agree with the statement “I am fearful that my circle of friends would think I was dumb for caring about concussions” (Bloodgood et al., 2013). Based on the apparent increase in concussion knowledge in coaches, athletes and parents within the last decade, one would expect to see an increase in the number of diagnosed concussions, which appears anecdotally to be the case. However, a number of studies have demonstrated that athletes continue to play while experiencing symptoms of concussion (Baker et al., 2013; Chrisman et al., 2013; Hollis, Stevenson, McIntosh, Shores, & Finch, 2012; Meehan III, Mannix, O'Brien, & Collins, 2013; Johna K Register-Mihalik, Kevin M Guskiewicz, et al., 2013). This phenomenon will be explored further within this paper for potential reasons for this lack of reporting by athletes.

Many US states have enacted legislation that requires athletes to be removed from play if they have suffered a suspected concussion, and they may not return to play until they provide a note from a physician (Chrisman et al., 2013). Further, if passed, “Rowans Law”, which has reached the committee level in the Ontario Legislature, would be the first law in Canada addressing sport concussion. These laws also stipulate concussion education for coaches, athletes, and parents; however, they haven’t created provisions for concussion detection. This creates the potential for athletes to knowingly hide their symptoms because they do not want to be held out of sport, and there is no consistency in assessment techniques.

While objective sideline and clinical tests are a necessary part of concussion assessment and return to play decisions, if an athlete is not assessed while they are suffering the symptoms of concussion, those tests are of no use. Increasingly, researchers are investigating reasons why athletes choose not to report their injury to teammates, parents, coaches or medical personnel, and the qualitative aspect of these studies allows further insight into the thought processes of athletes who have decided to play through their injury. While many of studies have placed their main focus on symptom reporting and objective measurements, there is often a component of the research that looks at attitudes and psychological factors as a portion of the data gathered in the study (Baker et al., 2013; J. S. Delaney et al., 2002; Johna K Register-Mihalik, Laura A Linnan, et al., 2013b). It is when looking deeper into the attitudes, intentions and actual behaviours that one builds a better picture of why athletes are not reporting their concussions. There are a number of themes that emerge when investigating the reasons why athletes do not report their head injury to medical personnel, e.g. not understanding that the symptoms that they are experiencing are those of a concussion; not wanting to miss games or practices; and the attitude that athletes are supposed to play through injury (the "culture of risk"). These themes will be explored in this paper, in relation to current research as well as gaps in the research that need to be filled through further study.

Qualitative research, including interviews and surveys with athletes, gives insight into the knowledge and attitudes that these individuals feel towards injury, and more specifically, to concussion. One of the major themes that emerges in such studies is that of athlete understanding and education of the signs, symptoms, and severity of concussion. This is a significant factor in detection of head injury in athletes, because if athletes do not understand that their symptoms are those of a concussion, or they do not believe that concussion is a serious injury, athletes are less likely to report. As previously mentioned, a number of states and institutions (including the NCAA) have mandated concussion education for athletes, coaches, and in some cases, parents. The hope of these programs is that increased knowledge and awareness will encourage

athletes to report head injuries and decrease the number of athletes who continue to play while concussed. A recent study among Irish Under 20 rugby players to assess basic concussion knowledge and attitudes found that even after athlete education, 8% of athletes believed that being “knocked out” was required for a concussion diagnosis (Baker et al., 2013). On a more positive note, the same study found that 85% reported that they would inform someone if they thought that they had suffered a concussion, and 83% would do so for a teammate who they believed had suffered a concussion. This would indicate that the attitude of these athletes toward reporting was quite good, and that they understood the importance of reporting a concussion. However, without good understanding of what signs and symptoms constitute a concussion, there would still be a large cohort of athletes who would still not report. Baker also found that there was a positive correlation between symptoms listed on the questionnaire and the number of previous concussions, leading the researchers to conclude that it is through previous concussion experience that players obtain concussion knowledge, not through organized education programs (Baker et al., 2013).

Media and education programs often focus on the seriousness of concussion (Anderson & Kian, 2012; Kroshus, Daneshvar, et al., 2014; Ruhe, Gänsslen, & Klein, 2014) and aim to encourage reporting in athletes so that they can avoid the consequences of playing while concussed. A study performed on Canadian football and soccer players examined the incidence of concussions among these athletes. Using self-reported symptoms and the number of concussions experienced by the players, the researchers determined that although 62.7% of the soccer players experienced symptoms of a concussion, only 19.8% of them actually realized that they had experienced a concussion (J. S. Delaney et al., 2002). Using a questionnaire that asked questions regarding general background, soccer history, past concussions and then looking specifically at the season in terms of games played and symptoms experienced, the investigators determined that female players were 2.6 times more likely than males to suffer a concussion, and that 46.2% of the soccer players experienced symptoms of a concussion during the fall season alone (while 62.7% experienced symptoms over the entire year). Interestingly, there were 5

episodes of loss of consciousness in soccer players that had been hit in the head that were not recognized by the athletes as a concussion. The fact that these athletes did not recognize that the symptoms that they have represent a possible concussion likely means that they did not seek medical attention for their injury. In previous studies it has been found that up to 20% of athletes who play football or soccer experience headaches while playing (Sallis & Jones, 2000), which is a confounding factor in Delaney's study, as not all headaches experienced by the athletes in his study may have been concussions. However, it was noted that if only those players who experienced loss of consciousness or confusion were included, 36.3% of the soccer players would still have been considered as experiencing a concussion (J. S. Delaney et al., 2002). Another study investigating the head injury knowledge in collegiate athletes was performed in 2003 by Kaut et al. Results indicated that 28.2% of all athletes in the study continued to play while dizzy, and specifically, 17.7% of male soccer players failed to report the dizziness to medical personnel and continued to play. The study also found that 30.4% of all athletes played with a headache after being hit, and in particular, that 26.7% of male soccer players did so (Kaut et al., 2003). The researchers also found that only 43% of the athletes reported having "some knowledge" in the area of the problems associated with head injury and concluded that athlete education needed to be improved as such a high number are continuing to play with symptoms.

Following those studies, McCrea et al. investigated the frequency of unreported concussion in high school football players (Michael McCrea et al., 2004). He found that only 47.3% of players reported their injury, with 66.4% stating that they did not think the injury was serious enough to warrant reporting, and 36.1% citing a lack of awareness of the severity of the injury as to why they didn't report. When the players were presented with a definition of concussion and description of the signs and symptoms of concussion, the players more readily recognized and admitted to sustaining a concussion over the course of the football season. Research in the late 1990's and early 2000's strongly pointed to a lack of knowledge of signs and symptoms and understanding of the consequences of head injuries. More recent studies have

looked at whether these education goals have been met, and what effect it has had on athlete reporting behaviours.

Chrisman et al. assessed barriers to reporting in high school athletes and found that athletes know that concussions are dangerous, but that most athletes would still play with concussive symptoms (Chrisman et al., 2013). In a group interview, when given four hypothetical scenarios that discussed symptoms (but did not use the word "concussion"), nearly every group came to the conclusion that they would keep playing with symptoms – 6 of 9 groups decided that they would keep playing and see how it felt, and the other 3 groups said that they would "take a little break" but likely go back in. One of the reasons mentioned by the athletes in this study was that with concussion, it is hard to tell if you are injured. Once again, the idea of concussion being an "invisible injury" is reported, so even though the athletes are experiencing symptoms of concussion, they are not likely to report them because there is no obvious injury to their body. Chrisman et al. concluded that even though other studies had found that athletes do not report symptoms of concussion due to a lack of knowledge, in fact, high school football and soccer players do know a great deal about concussion. However, even with this apparent knowledge, when focus groups were presented with scenarios of various concussion mechanisms, participants still would not report their injury. Mansell and colleagues took a different approach – they looked to evaluate the association between an athlete experiencing a previous concussion and reporting signs and symptoms after a subsequent hit (Mansell et al., 2010). They found that 59% of athletes without a previous concussion reported symptoms after a hit to the head, compared to 80% of previously concussed athletes who reported symptoms. All of these instances were in non-documented concussions, indicating that athletes with a history of concussion (who likely had knowledge of concussion as a result of their previously diagnosed concussion) were choosing not to report their new symptoms, even though they were aware of the common signs and symptoms, and likely, the consequences.

Another recent study that investigated the number of athletes reporting continuation of play while symptomatic found that only 40% of concussion events and 13% of "bell ringer"[1] events were disclosed to medical staff (J. K. Register-Mihalik et al., 2013). One of the main reasons cited for athletes not reporting their symptoms was not thinking that it was serious enough to warrant reporting (70.2%). The study assessed athlete knowledge regarding concussion and found that increased athlete knowledge resulted in increased reporting of events occurring in practices, and those referred to as "bell-ringers". An interesting aspect of this study is the investigation of athlete "attitudes towards reporting", which found that those athletes with a more positive attitude towards reporting symptoms were more likely to report during games and practices, and were less likely to participate in games or practices while symptomatic. This suggests that athlete's attitude plays a large role in their decision to report concussion symptoms to coaches or medical staff.

More recent studies would indicate that athlete knowledge about the signs and symptoms has improved with the introduction of education systems within teams and sport organizations, however, the number of athletes who continue to play while experiencing symptoms remains high. This is evident in a study by Rivara et al. in 2014, who investigated the number of high school athletes who played with concussive symptoms and the effect of a mandatory concussion reporting system. They found that 69% of high school athletes in the study reported playing with symptoms, and that among concussed athletes, 40% played while symptomatic without their coach knowing that they were concussed, despite having to sign a statement at the beginning of the season stating that they would disclose all symptoms to the coach (Rivara et al., 2014). These findings were consistent between a number of different sports, including girls soccer and boys football, and found that only 1/3 of athletes who experienced symptoms consistent with a concussion received a concussion diagnosis. While concussion education is an important tool to have coaches, parents and athletes on-

[1] Bell-ringer Definition – "A momentary state of confusion or disorientation that results after being hit on the head" (www.knowconcussion .org)

board with symptom reporting and concussion diagnosis, it would appear that there are still other reasons why athletes are not reporting their symptoms to medical personnel.

Invisible Injury

In his research on concussions, Gordon Bloom discussed the "uniqueness" of concussion as an invisible injury, which causes its own set of problems in assessment and treatment, over and above the actual signs and symptoms of the injury (Bloom, Horton, McCrory, & Johnston, 2004). Due to its lack of obvious physical signs, it is difficult for an observer, whether parent, coach or teammate, to identify an athlete as concussed; which can cause anxiety and frustration on the part of all parties when an athlete looks healthy but is still unable to participate in his or her sport. Another confounding factor in the process of concussion management is the overlap of post-concussion symptoms with the "normal" psychological response to injury. The same symptoms of headache, anxiety, sleep-disturbance, and altered mood are all diagnostic indicators of concussion, however, they are also common complaints of athletes with musculoskeletal injury as they proceed through the healing and rehabilitation (Bloom et al., 2004). These issues make accurate and consistent concussion assessment difficult for even the most highly trained neuropsychologist, so research has focused on creating objective and sensitive cognitive tests that can be used clinically and "in the field".

Recovery from concussion is a complex process that, while usually occurring within 7-10 days of injury, can be prolonged and involves physical and psychological factors. Post-concussion symptoms vary in accordance with stress levels, coping style, cognitive appraisal, and psychological vulnerabilities (Gouvier, Cubic, Jones, Brantley, & Cutlip, 1992; King, Wenden, Caldwell, & Wade, 1999). A number of factors contribute to the recovery from concussion – initial symptoms may be physiological in nature, but persistent symptoms may involve psychological factors (Mittenberg & Strauman, 2000). It is a unique injury in that over the course of the rehabilitation process an athlete may lose physical fitness (cardiovascular fitness, strength, and power) because they are not able to train any of those systems due to a recurrence of signs and symptoms. This

contributes to the negative psychological and social factors previously discussed and may slow the recovery process even further.

Researchers estimate that between 1.6 and 3.8 million sport-related concussions occur in the United States every year (Langlois et al., 2006), which is likely an under-estimation due to the fact that research had shown that 50-75% of sport-related concussions go unreported (McCrea et al. 2004). In 2006, Williamson and Goodman performed a retrospective survey with the BC Minor Hockey Association which found a significant difference between the number of concussions officially reported to the association and those reported by the players and team volunteers (Williamson & Goodman, 2006). They found that only 0.25-0.61 concussions per 1000 player game hours (PGH) were officially recorded, while elite players reported up to 24.3 concussions per 1000 PGH when surveyed post season. This set of findings is similar to those of Delaney et al., who found that 62% of collegiate soccer players and 70% football players experienced a concussion during the 1999 playing season, however, only 12% of the soccer players recognized that they had experienced one (J. S. Delaney et al., 2002). What was not examined in either study was the reason why there was such a large discrepancy between the assessment of a concussion by team medical staff and the reporting of signs and symptoms by athletes in the post-season. Some researchers question whether it is a lack of education into the signs and symptoms of concussion that result in lower reporting incidence to medical or team officials (Bramley, Patrick, Lehman, & Silvis, 2012), whereas others suspect that it is a conscious decision by athletes to knowingly hide their symptoms. A recent study by Torres found that 43% of collegiate athletes with a history of concussion had knowingly hidden symptoms to stay in a game, and 22% of athletes overall reported that they would be unlikely or very unlikely to report symptoms to a coach or trainer (Torres et al., 2013). Regardless of lack of concussion awareness or knowingly hiding symptoms, the consequences of unrecognized concussion are potentially dire.

A much more common occurrence in athletes is the presence of post-concussion symptoms lingering long after the expected 7-10 day recovery time. Covassin and colleagues determined that high school athletes take longer to recover from concussion than their collegiate counterparts. In her study, 293 high school and collegiate athletes were given pre-season neuropsychological tests, and those tests were repeated at 2, 7, and 14 days post-concussion. The results showed that high school athletes displayed memory impairment 7-14 days post-concussion, and reaction time impairment for 14-21 days post-injury. This is in contrast to collegiate athletes whose auditory attention and processing speed had resolved within 5 days of injury. It is important to note that the athletes displayed significantly more self-reported symptoms at 7 days post injury than at baseline, and had returned to their baseline symptom scores by 14 days (Covassin, Elbin, Harris, Parker, & Kontos, 2012). On the other hand, in 2006 McClincy et al., using data collected over 30 months in high school and collegiate athletes, found that neurocognitive deficits exist up to 14 days post injury, with verbal memory taking the longest to return to baseline levels. It is important to note that these deficits existed even when the subjects reported no subjective symptoms (McClincy, Lovell, Pardini, Collins, & Spore, 2006). However, in his study, McClincy mixed high school and collegiate athletes in his cohort, and had a mean age of 16.1 years; which would indicate that most of his subjects were in high school and may explain the longer recovery times.

Return to Play Decisions

In the absence of objective, reliable and valid neurocognitive testing it is unrealistic to expect that return to play decisions can be based solely on objective criteria. The practitioner must be able to make use of subjective data, existing neurocognitive testing and clinical interviews in order to determine the most appropriate treatment and return to play plan. Unfortunately, the aspect of sport that makes it so appealing for athletes, coaches and spectators – the emotion and competitiveness – also mean that return to play decisions are not based solely on deductive reasoning, objectivity and logic, often to the detriment of the health and safety of the concussed athlete. The return to play

decision is a complex interaction of many factors that the decision maker must constantly evaluate in a risk-benefit evaluation (Echemendia & Cantu, 2003), and the integrity of the baseline evaluation is a key factor in that decision. Without the ability to tease apart the weaknesses of both self-reporting scales and neurocognitive testing, medical personnel tasked with making the return to play decision for an athlete who is likely feeling stress, pressure and anxiety with the process, cannot be assumed to be safe and effective.

Sport has many physical, psychological and social benefits for those who participate, who often identify themselves as “an athlete”. This title comes with a certain sense of self identity and attitude toward participation, which manifests itself in a strong desire to participate in practices and games. For collegiate athletes, additional considerations such as scholarships, peer acceptance, and the support of coaches may add to this identity and increase their internal drive to participate even when injured (Johna K Register-Mihalik, Laura A Linnan, et al., 2013a). The desire to participate may override an athlete’s understanding of the seriousness of concussion and cause them to lie about or hide their concussion symptoms. This is another strong theme that emerges in research into non-reporting of concussion symptoms by athletes. The previously discussed study by Chrisman et al (2013) found this to be the case during group interviews using hypothetical scenarios of symptoms occurring after a hit to the head. The athletes in the study mentioned playing their sport because they enjoy it and they worked and trained hard in order to play. They understood that if they report symptoms, they might be pulled from the game. These same athletes are also tied to their coaches and teammates and feel internal pressure to not let them down by leaving the game or practice. Similarly, when Delaney et al investigated concussion reporting in university athletes, along with not realizing that their symptoms were evidence of a concussion, the athletes also expressed that they were honest about their symptoms due to the retrospective nature of the study (J. S. Delaney et al., 2002). The authors noted that although using a retrospective study has its limitations because it relies on athletes remembering and reporting on their symptoms, the athletes could be more

honest because they knew that they would not be removed from play. This is consistent with a similar study on professional football players who admitted that they were reluctant to answer truthfully about their concussion symptoms because they were fearful that they would miss playing time or lose their spot on the team (J Scott Delaney, Lacroix, Leclerc, & Johnston, 2000).

A 2011 Australian study investigating compliance with return to play regulations among rugby players found that 22% of the players in the study reported being given post-concussion advice telling them not to return to play, and all players ignored the advice and returned to play anyway (Hollis et al., 2012). At the time of the study the International Rugby Board (now World Rugby) had developed a stringent concussion policy that stated that all players who suffered a concussion should sit out for 3 weeks from training and games. The Australian Rugby Union (ARU) had adopted this policy for players under the age of 19 and for coaches of these players, which means that any age-grade player who self-reported symptoms of a concussion would automatically miss 3 weeks of practice or play, which is a significant amount of time in a short playing season. The ARU also recommended the same policy for all players, regardless of age. While only some of the athletes involved in the study were under the age of 19 (and therefore mandated to sit out for 3 weeks), 95% of the participants in the study ignored the advice of medical personnel and returned to rugby before they were medically cleared or the 3 week stand-down period had passed (Hollis et al., 2012). A study of New Zealand rugby players also found that 22% of the athletes who had sustained a concussion returned to play against physician orders, and over half returned to play without medical clearance (Sye, Sullivan, & McCrory, 2006). These results are similar to those found in a study of Canadian hockey players, which found that 33% of players who had been told by a physician that they should not return to play after a concussion began playing against medical advice (Ackery, Provvidenza, & Tator, 2009).

Aforementioned studies share the common theme of intentional non-compliance with medical advice from physicians stating that these athletes (who had sustained a

concussion) could not safely return to play. The studies did not have a provision for asking why the athletes chose to return to play before it was medically safe to do so. Anecdotal reports of desire to play and feeling like they were missing out on training and game play are consistent in the research.

In his study "The Lived Experience of an In-Season Concussion Amongst NCAA Division 1 Student Athletes", Moreau and colleagues interviewed concussed athletes to examine their experiences and feelings after suffering a concussion during their season (Moreau, Langdon, & Buckley, 2014). The findings suggest that athletes struggle with the perceived pressure from teammates and questions regarding the severity of the injury that coincides with the requirement that they are held out of games and practices. Because the athletes do not have any obvious physical injury, their teammates, peers, and coaches cannot determine the extent of their injury. This adds to the pre-existing internal pressure and desire of the athlete to return to play, which was anecdotally reported to cause athletes to return to play even while still symptomatic. The athletes in the study frequently cited an unwillingness to leave a game (desire to play), and fear of letting teammates down as reasons why they wouldn't report their symptoms. In fact, the author wrote "based on her interview comments, it is plausible to suspect that if Sally suffered a repeat concussion she may be dishonest in her symptom reporting and or encourage a teammate to be dishonest", further reinforcing the theme of athlete desire to participate.

In other studies, collegiate age athletes were interviewed and approximately 20% believed that they should be responsible for return to play decisions after suffering a head injury (Livingston & Ingersoll, 2004), while close to 1/3 of athletes in another sample believed that it was okay to wait until the end of a game or practice to report concussion symptoms (Sefton, 2003). The drive to continue playing after injury or return to play before it is safe to do so is often lauded by teammates, coaches and fans, and may contribute to the athletes' internal desire to continue playing even when they know it is not safe to do so. Authors of a study investigating numbers of symptoms reported

over time in concussed high school and collegiate athletes noted that athletes may minimize the effects of their concussion in order to be cleared to play faster (M R Lovell et al., 2002).

A conclusion reached by Rivara on the effect of coach education on concussion reporting was that the attitude of athletes toward concussion reporting is as important as concussion education, and in fact can create a major barrier to the proper care of concussed athletes (Rivara et al., 2014). Legislation requiring concussion education has little effect on athletes' attitudes toward concussion reporting is negative and their desire to play overrides all other considerations.

"Culture of Risk"

A 2006 sample of high school athletes found that approximately 50% of the study participants had returned to play after suffering a concussion without medical clearance, and 27% believed that the importance of the game should influence return to play decisions (Sye et al., 2006). The same study also found athletes reported that a player on their team had been pressured to play despite being concussed. A similar study on American high school soccer players stated that only 88% of the athletes would report a concussion to their coach in a championship game, while 97% would do so in a regular game (Bramley et al., 2012). While it may be assumed that high school athletes may not have as strong an understanding of the health issues involved with returning to play while still suffering symptoms of a concussion, the notion that the importance of the game should influence the decision to return to play is indicative of a "culture of risk" within sport that causes both internal and external pressure on athletes to play through a concussion.

The culture of risk is evident through all ages and levels of athletics and can result in athletes returning to play (or continuing to play) while concussed. Coined by sport sociologists, the "culture of risk" describes a state where being able to play through pain and injury are considered desirable attributes or traits for athletes, and are linked with toughness, strength, and commitment (McGannon et al., 2013). This culture encourages

athletes to undertake risky behaviour and encourages and/or rewards pain and injury – athletes understand this and in order to gain respect by teammates or achieve top performances, jeopardize their health and safety (Nixon, 1992, 1993). This can create psychosocial issues for athletes such as emotional trauma, anger, social isolation, depression, pain and pressure to return to play after suffering an injury (Kontos, Collins, & Russo, 2004; Mainwaring, Hutchison, Bisschop, Comper, & Richards, 2010). This may be especially problematic when dealing with concussed athletes, as their injury cannot be seen by others and signs and symptoms vary so dramatically between people. In high school and collegiate level athletes, the still-maturing brain and sense of invincibility that as associated with youth, in addition to the pressure felt in the culture of sport, may override the education and reporting systems that teams and organizations work so hard to put in (Chinn & Porter, 2013).

Athletes in Chrisman's study, while discussing knowledge of concussion symptoms and the desire to keep playing, also commented on the notion that, as an athlete, you are supposed to play injured (Chrisman et al., 2013). The participants in the study did not feel that it was acceptable to leave a game for non-specific symptoms (those associated with a concussion), and remarked that even though they knew that what they were feeling were symptoms of a concussion, they did not want to look weak in front of coaches or teammates. One football player noted "You don't want to look like a baby", while a female soccer player commented "…I'd probably be like, 'I'm going to keep playing because I need to suck it up and show that I'm not a wuss'" (Chrisman et al., 2013). Male athletes, who as a result of notions of masculinity and pain within this culture may return more quickly than their female counterparts after injury (Nixon, 1993), are under added pressure to perform within this context, and their health and safety may suffer as a result. Granito suggests that male athletes often feel more pressure from their teammates or coaches to play through pain or injury than female athletes do. As a result of this pressure, male athletes who are removed from play may experience "reactive depression" because they are no longer self-identifying in a positive way within the sport culture (Granito Jr, 2002).

It is not just athletes who must work and perform within the culture of risk that sport embodies, coaches and medical personnel are also deeply embedded within this culture and make decisions within that context. Research by Chinn on compliance with return to play regulations within community colleges in California demonstrated that Athletic Trainers also work under the pressure of the culture of risk. When asked to discuss the pressure placed on them by athletes to allow them to return to play too early after suffering a concussion, 52% of trainers reported a moderate amount of pressure, while 41% reported a high degree (Chinn & Porter, 2013). The trainers in the study also discussed pressure from "old school" coaches to return athletes too early, and mentioned that "some coaches perceive playing through an injury such as a concussion as an inherent part of the sport" (Chinn & Porter, 2013 p 418). Those trainers noted how difficult it is on the athletes who feel this pressure from the coaches to come back to play while they are still symptomatic. However, the trainers also feel pressure because they know that athletes are not reporting symptoms to them for fear of being removed from the game, and they are responsible for returning athletes to play as soon as (safely) possible after a concussion but they have to rely so heavily on subjective symptom reporting in order to do so. Many of the trainers also discussed the immense workload that proper concussion management places upon them, in addition to the other components of their job. One trainer commented,

> "In the past I was at all of the practices during the contact, and we had a lot more concussions. Last year, I did not go to practices, and we had a major decrease in reported concussions… So the questions I wanted to propose was how do you explain head injuries going down when I'm not at practice? Maybe I should just stop going to practice! Seriously, I know what's going on".
>
> (Chinn & Porter, 2013 p. 419)

Clearly the Athletic Trainers in Chinn's study were working within a sociocultural framework that places added pressure on athletes (from teammates and coaches) as well as members of the medical staff to have athletes play through injuries and risk future health in order to play as soon as possible. For Athletic Trainers and Therapists, game-time return to play decisions often have to be made in and around noisy areas

where athletes are distracted by the game itself and coaches and the players are pressuring the medical staff to return the player as quickly as possible.

The National Hockey League (NHL) and World Rugby have both instituted the "quiet room" as a place for medical doctors to assess any athletes who are suspected of having a concussion during game play. The idea of this is to remove the athlete from the noise and pressure of the sideline or bench and allow for more vigorous testing, and hopefully, honest symptom reporting from athletes. Unfortunately, this also requires recognition of the potential injury in the first place, and removal of the athlete from play while tests are performed. While the NHL and World Rugby are attempting to more effectively recognize and assess concussions in their players, the 2014 Soccer World Cup was evidence that not all sports or sports organizations are yet on board. In a number of games, players were either knocked unconscious or appeared visibly "out of it" and were allowed to keep playing. In one case, the team physician appeared to motion for a stretcher and substitution for the injured player, but the player refused and continued to play. While one could understand the pressure on the athlete to play at the highest level of competition that his sport offers, and his unwillingness to leave the field of play, it was obvious that the medical staff had either no control over the decision making process, or were as caught up in the importance of the match as the player was and allowed him to continue playing. Earlier interviews with sports medicine personnel at a large Canadian university illustrated that they are familiar with the risk culture in sport that athletes "buy into" that tells them that they should play through pain and injury. So they try to temper it with a "culture of precaution" that works to educate athletes as to the implications of playing while injured, and forcefully communicating with athletes the importance of their symptoms (Safai, 2003).

In 2013, researchers attempted to understand concussion in a sociocultural context by looking at the media portrayals of Sidney Crosby's concussions in the 2011 NHL season. One of the overarching narratives that researchers discovered in the analysis of articles on his injury and return to play was the "culture of risk and the impact it has on

athletes" (McGannon et al., 2013). The authors noted that "the cultural values of sport further link pain tolerance with masculinity and a desirable identity for athletes to obtain and uphold" (p. 894), and that athletes understand this narrative and work to place themselves within it. Pain and injury are presented as a "normal" part of sport, and therefore when athletes suffer an injury and are no longer upholding that norm, they suffer not only the physical damage that comes along with the injury, but also psychological and social effects. Institutional norms within the sport culture may also contribute to athletes hiding or lessening their symptoms in order to continue participating. The media analysis undertaken by McGannon and colleagues also noted that while the media regularly reports on the physiological effects of concussion, they often don't discuss the social and psychological issues that come along with them. After being removed from sport, athletes "may be left without agency and power, suffering in silence when they have psychological symptoms" (McGannon et al., 2013). Within the culture of risk that embodies sport, the notion of concussion as strictly a physiological problem may mean that athletes are even less likely to discuss their symptoms because they have been brought up within the culture that cannot even recognize the objective signs of injury, let alone the subjective and hidden symptoms. This may lead to feelings of embarrassment about reporting these symptoms and further increase the risk to athletes.

Socio-ecological Framework

As researchers look to quantify the number of concussions in athletes that go unreported, a number of explanations have been formulated which encompass many of the factors previously discussed. The socio-ecological framework looks at how multiple levels of influence interact to determine health behaviours (Kerr et al., 2014), and "works on the assumption that human behaviour is best understood when all levels of the ecological system are considered" (Bronfenbrenner, 1977; Kerr et al., 2014). When looking at all influences on an athlete, one can start to gain a perspective as to how their behaviour is affected by intrinsic and extrinsic factors which lead to the potential for

non-disclosure of injury; specifically concussion. Once these factors are better understood, strategies can be developed to overcome the issues that face medical personnel when dealing with concussed athletes. The socio-ecological framework looks at four specific levels of influence 1) Intrapersonal (e.g. individual characteristics), 2) Interpersonal (e.g. relationships with other individuals), 3) Environment and Social, and 4) Policy (Kerr et al., 2014). All of these factors play a role to some extent in the reporting of symptoms of a concussion in an athlete, and can be seen in the themes already discussed in this paper.

On an intrapersonal level, lack of awareness and understanding of the seriousness of concussion, and what signs and symptoms constitute a concussion are important factors in an athletes' disclosure of their injury. If he or she does not understand that what they are feeling are symptoms of a concussion, they will not report their injury to medical personnel. An athletes' attitude towards concussion reporting is also a major factor in the intrapersonal aspect of the socio-ecological framework. If an athlete feels internal pressure not to report or has a poor attitude about reporting and the associated outcomes, he or she is much less likely to report (J. K. Register-Mihalik et al., 2013; Johna K Register-Mihalik, Laura A Linnan, et al., 2013a).

Athletes assimilate into the "culture of risk" as they move to higher levels in sport participation and this certainly could have an effect on their intrapersonal response to concussion. The risk culture inherent in sport also plays a role in the interpersonal and social aspect of the socio-ecological framework of concussion reporting. Athletes in a number of previously mentioned studies reported pressure from coaches and teammates to continue playing after suffering a concussion (Bramley et al., 2012; Chrisman et al., 2013; Rivara et al., 2014; Sye et al., 2006), while Athletic Trainers and other medical personnel have also reported the same type of pressure from coaches and athletes to return a concussed player too early (Chinn & Porter, 2013; Safai, 2003). While teammates and coaches are also developing within the culture that rewards toughness and playing through pain and injury, athletes are experiencing pressure from

these other parties to “suck it up” and play through their injury. This may be especially difficult in the case of concussion, where objective tests are difficult to perform on the sidelines and others are not able to see the effects of the injury because there are often no physical manifestations.

Finally, from a policy perspective, while a number of institutions have created mandatory concussion education policies for athletes, coaches, parents and medical staff, it is difficult to ensure that these systems are being followed, and athletes are often still willing to hide their symptoms even once they are aware of potential consequences of doing so.

Gaps in the Literature

Many of the qualitative studies undertaken on reporting of concussion in athletes have illustrated 3 major themes – athlete knowledge and understanding of concussion, athlete attitude toward concussion reporting (and wanting to play), and the “culture of risk” that athletes are living in and identify with even while they are injured. These factors, compounded by the fact that concussions are hidden or “invisible” injuries with very few objective tests, means that athletes, who are likely highly motived to continue playing even while symptomatic, are not being recognized as concussed and may be increasing their risk of future health problems. However, there has been little investigation into the experiences of athletes who have acknowledged not reporting or delaying reporting concussion symptoms (Moreau et al., 2014), and combining the use of self-reporting, knowledge and attitude into one study (J. K. Register-Mihalik et al., 2013).

Many tools used for the assessment of concussions in athletes involve subjective reporting of symptoms by the injured athlete (e.g. ImPACT, SCAT3) and decisions regarding return to play for athletes with a suspected or diagnosed concussion often involve the use of subjective reports. Many tools have been developed for the objective testing of athletes with suspected concussion (e.g. BESS, ImPACT, King-Devick),

however, the “art” of concussion assessment by medical professionals often involves speaking to athletes and eliciting honest responses about concussion symptoms. In fact, in a study of Certified Athletic Trainers found that 85% used self-report checklists to determine return to play status (Chinn & Porter, 2013). Athletes have many intrinsic and extrinsic reasons to lie or omit symptoms when concussed which involve lack of knowledge about concussion symptoms and ramifications of playing while concussed, negative attitudes about reporting, and being involved in the sport culture, which values toughness and playing through injury. If self-report scores are one of the main methods that medical personnel are using to determine an athletes’ readiness to return to play, and athletes are aware of this, they could lie on the test and be allowed to return before it is safe to do so. Research has found that anywhere from 18 to 66 percent (Baker et al., 2013; J. S. Delaney et al., 2002; Kaut et al., 2003; Michael McCrea et al., 2004) of head injuries go unreported by athletes, which would indicate that sport-related are significantly more common than previously believed.

It is estimated that 15% of non-elite athletes in team sports sustain at least one mTBI per year (McManus, 2006), which has implications for university teams and athletes who have the potential to miss a large portion of their season if they are diagnosed with a concussion. University-level athletes also have the added factor of needing to be able to perform academically during the time that they are playing their sport. Since each term is a very short amount of time with many assignments, tests and exams, if significant time is missed due to a concussion, a student-athlete may fall behind his or her peers academically, which may jeopardize their athletic career if they do not maintain minimum participation grades. This places a student-athlete in a difficult situation – on one hand, they have the motivation to lie about symptoms in order to continue playing, however, if they are symptomatic while attending classes and suffer cognitive deficits as a result, their academic standing may be compromised. Understanding how athletes balance these two competing factors and justify their decision to either report or not report symptoms of a concussion will help in future concussion education and detection among collegiate-age athletes.

Existing quantitative research into non-reporting of concussion symptoms by athletes has focused on determining the reasons why they did not report, as well as concussion knowledge of the participants (Chrisman et al., 2013; Michael McCrea et al., 2004; Moreau et al., 2014). Quantitative research is limited to reporting the data and does not allow for further expansion and exploration of reasons why athletes do not report concussions. On the other hand, interviews and qualitative research proves to be an excellent method for investigating the attitudes and feelings of athletes regarding concussion reporting and their experiences with concussion; however, the small number of studies performed make the findings more difficult to generalize. When performing qualitative studies, the use of purposeful sampling to understand the experiences of the individual is the main goal, and is case-oriented, not variable-oriented as is the case with quantitative data gathering (Sandelowski, 1995). Open-ended interviews or "directed conversation" allow the interviewer to explore themes and concepts and allow the participant to tell their story, which the interviewer can then place into the social framework that they are working under (Charmaz & Belgrave, 2002).

The present study utilizes a mixed-methods design with the quantitative data informing the qualitative (QUAN → qual), allowing the research question to be addressed in both an exploratory and explanatory way. This provides a fuller picture and allows for the fleshing out of findings derived from the quantitative portion to better explain the process that athletes undergo when deciding not to report their symptoms of concussion. By interviewing student-athletes about their experience with concussion symptoms and the discussing the decision-making process they undertook in order to determine if they would report these symptoms to medical personnel, and tying that into their personal beliefs and behaviours, a large gap in the existing literature will be filled.

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Chapter 2 - Manuscript 1:

Effect of Knowledge, Attitude, and Intention on Concussion Reporting Behaviours in Varsity Athletes

Abstract

Background & Purpose: Concussions in university age student-athletes can lead to missed game and practice time and decreased academic performance. Under-reporting rates have been found to be over 60%, which has potential catastrophic consequences if concussions are not assessed or managed properly. This study examined levels of concussion education, attitudes, behaviours and intentions toward concussion reporting in varsity-level athletes.

Methods: Men's and women's hockey and soccer, and women's lacrosse players at a mid-sized Canadian university completed the "Rosenbaum Concussion Knowledge and Attitudes Survey- Student Version (RoCKAS-ST), "Head Injury Questionnaire", and "Post-Concussion Scale" (PCS) at pre- and post-season. Concussion knowledge was measured at pre-season, and pre- and post-season intentions, attitudes and behaviours were examined. At post-season, participants were divided into "symptoms reported" and "no symptoms reported" categories and a two-way repeated measures ANOVA was utilized to measure changes in attitude.

Results: Ninety-six participants completed the pre-season survey, and 78 completed at post-season. At the end of the 2015 fall varsity season, 29% of participants (n=23) had experienced symptoms that they felt may have been from a concussion; of this group, 43% failed to report their symptoms to staff. Knowledge of concussion signs and symptoms was high, with 91.7% of all knowledge and education questions answered correctly. Both groups demonstrated a trend toward less-safe personal reporting intentions even though their attitude toward concussion was generally "safe". Overall, there was no significant difference between groups in attitude, reporting intention, or behaviour.

Conclusion: Knowledge of the seriousness and signs and symptoms of concussion is high, but reporting intention and behaviours are not reflecting that knowledge. Participants have an expectation of “safe” reporting behaviours in others, but not necessarily for themselves. Therefore, other influences that could lead to underreporting need to be explored.

Introduction

Media reports of concussion in professional athletes and the potential catastrophic consequences of returning to play after concussion provide fodder for pundits to discuss the safety of certain sports and the effectiveness of concussion assessment and management. Unfortunately, athletes are often allowed to return to play too early after suffering a concussion, or their concussion is not recognized in the first place; subjecting the athlete to possible long-term negative consequences, including death. The reported number of sport-related concussions in the United States is varied, ranging from 300,000 to 4 million per year (Colvin et al., 2009; Covassin et al., 2007; McGannon et al., 2013), however, it is widely believed that these numbers are underestimated due to lack of reporting by athletes (Barnes et al., 1998; Boden et al., 1998). A contributing factor, and one of the most difficult issues to deal with in concussion assessment and management, is that concussions are an "invisible injury", which often means that athletes must approach medical personnel, coaching staff, or teammates with complaints of symptoms in order for their injury to be detected. Research has demonstrated that athletes are aware that concussions are dangerous, but that most would still play even though they are suffering symptoms (Chrisman et al., 2013). If this is in fact the case, the detection of concussion in athletes is an even more complex issue than simply the use of objective tests to quantify signs and symptoms.

As a category of mild traumatic brain injury (mTBI), concussions are defined as "a complex pathophysiological process affecting the brain, induced by biomechanical forces" (P. McCrory et al., 2013), which often don't involve pathological injury to the brain that is visible using imaging modalities, but instead is diagnosed based on clinical symptomology. The fact that loss of consciousness or other obvious signs do not always occur with concussion means that athletes can hide their injury and continue to practice or play. This potentially puts athletes at risk for long term cognitive impairments, or Second Impact Syndrome where a second concussion occurs before the first concussion

has healed leading to brain swelling and catastrophic consequences including brain herniation and death (Cantu, 1998).

Traumatic brain injury (TBI) resulting from sport participation occurs most frequently in people age 5-24, with 90% considered mild (Kaut et al., 2003). Among individuals aged 15-24, sports are the second leading cause of concussion behind motor vehicle accidents (Marar et al., 2012); as sport participation in youth increases, the numbers of sport-related concussion can be expected to rise as well. Collision sports like hockey, rugby, and football provide obvious mechanisms for concussion in almost every play; however, in studies of collegiate and high school athletes, soccer players had an extremely high incidence of concussion, despite the fact that it is not considered a collision sport (Tracey Covassin et al., 2003a; T. Covassin, C. B. Swanik, & M. L. Sachs, 2003; J. S. Delaney et al., 2002). Collegiate athletes are estimated to sustain 43 concussions per 100,000 athlete exposures to a game or practice, nearly double the rate of those experienced by high school athletes in similar contact or collision sports (Daneshvar et al., 2011). The actual incidence is unclear due to the high estimate of underreporting (up to 60%) (Broglio et al., 2010; Kroshus, Daneshvar, et al., 2014; Michael McCrea et al., 2004; Johna K Register-Mihalik, Kevin M Guskiewicz, et al., 2013; Torres et al., 2013), the potential public health issue created by improper management of these athletes is very serious. In collegiate athletes, who must balance high-level game play and training with the stresses of school, work, and social activities, concussion has been shown to have serious consequences on neurocognitive function, self-efficacy, and social interaction (Covassin, Stearne, & Elbin III, 2008; Hall et al., 2015; Moreau et al., 2014). For a collegiate athlete who must attend classes, complete assignments, and write tests, a decline in cognitive function, even in the short term, has the potential for serious long-term consequences.

It is estimated that between 50% and 75% of sports related concussions go unreported (Michael McCrea et al., 2004), however until recently, little work has been done to date to establish reasons why athletes hide symptoms from teammates, coaches, and medical

personnel. Torres and colleagues found that 43% of collegiate athletes with a history of concussion had knowingly hidden symptoms to stay in a game, and 22% of athletes overall reported that they would be unlikely or very unlikely to report symptoms to a coach or trainer (Torres et al., 2013).

Such high rates of under-reporting is further challenged by the use of clinical judgement in the absence of concrete, objective tests, despite research focused on the development of assessment tools to reliably detect concussions. While it is vitally important that concussions are detected early to prevent the previously mentioned consequences like cognitive deficits and Second Impact Syndrome, and objective tools to aid in the assessment are key, it is becoming increasingly apparent that detection and assessment of concussion is multi-faceted and often relies on the skill of the therapist or physician at interviewing and testing the athlete, and also on the athlete to be honest about his or her symptoms. To this end, concussion education has become an integral part of athletic programs at both the high school and university level (Echlin et al., 2010; Kroshus, Daneshvar, et al., 2014), and the hope is that with increased awareness among parents, coaches, and athletes themselves, more concussions will be recognized and reported to medical staff. In 2003 Kaut and colleagues undertook a study to examine head injury knowledge in collegiate level athletes; results indicated that only 43% of the athletes in the study had “some” knowledge about concussions (Kaut et al., 2003). However, more recent research found that 86% of Irish Rugby Union players believed that concussion was as serious as other injuries, and 75% believed that playing with a concussion could lead to long-term medical problems; despite this improved knowledge, 25% still reported playing rugby at some point whist they were knowingly concussed (Baker et al., 2013) . This would indicate that even with increased knowledge and awareness of the seriousness of concussion, athletes are still willingly hiding symptoms. Further to this, a study on collegiate hockey players found that providing concussion education caused no overall increase in knowledge or intention to stop playing when concussed (Kroshus, Daneshvar, et al., 2014). Qualitative studies examining barriers to concussion reporting have also concluded that players would continue playing with

symptoms of a concussion (Chrisman et al., 2013; Mansell et al., 2010; J. K. Register-Mihalik et al., 2013).

The purpose of this paper is to examine the reporting intention and behaviour, as well as the knowledge of the effects, signs, and symptoms of concussion of varsity-level athletes at a Canadian university. It was hypothesized that without an intervention of education regarding concussion, those who experience concussion over the course of a varsity season would have different attitudes toward concussion reporting than their non-concussed counterparts.

Methods

Participants

Men's and women's varsity soccer and hockey, and women's lacrosse players at a mid-sized university in Ontario, Canada participated in this study. These athletes compete in the Ontario University Athletics (OUA) conference within the Canadian Interuniversity Sport organization. Inclusion criteria included athletes between the ages of 17 and 25, not currently experiencing the symptoms of a concussion, and who were able to complete the written questionnaire. Institutional review board approval was received from the University of Ontario Institute of Technology (UOIT), and all participants provided informed written consent prior to participation. Participating athletes completed written surveys in August 2015 and again in November 2015, at the conclusion of the fall varsity season. The men's hockey team completed their second survey in December 2015, after their final game of the first half of the season.

Soccer and lacrosse teams completed the initial survey during a mandatory "Varsity 101" session, during which athletes are given instruction and education regarding their participation on a varsity team, while the hockey athletes completed the survey prior to baseline concussion testing. In order to ensure that the primary investigator, the varsity Athletic Therapist at UOIT, could not identify athletes who may have chosen not to

participate in the research, research assistants coded both the name and team for each participant.

After the final game of the fall season, participants were asked to complete a follow-up survey during a team meeting.

Measures

The pre-season survey measured both knowledge and attitude and intention toward concussion reporting, using Rosenbaum and Arnett's "Rosenbaum Concussion Knowledge and Attitudes Survey-Student Version" (RoCKAS-ST) (Rosenbaum & Arnett, 2010) and the attitudes and perceived consequences of reporting sections from Kroshus et. al.'s 2014 study on concussion reporting (Kroshus, Kubzansky, Goldman, & Austin, 2014b). Preseason attitude and behavioural intention was measured using the Concussion Attitude Index section of the RoCKAS-ST, utilizing a 5-point Likert scale to measure intention to report (1= strongly disagree, 5=strongly agree). A question that read "I would stop playing and report my symptoms if I sustained an impact that caused me to…" with a list of common signs and symptoms of concussion was also utilized, with responses placed on a 5-point Likert scale with 1 being "strongly disagree" and 5 "strongly agree". The RoCKAS-ST has been shown to have high face validity and adequate reliability (Rosenbaum & Arnett, 2010) and choosing to play while experiencing a symptom of a concussion is considered to be a "face valid proxy for symptom reporting intention as it reflects the individual's overall appraisal of their likelihood of engaging in the opposite behaviour of symptom reporting" (Kroshus, 2014, p. 2). Scoring was performed as outlined by Rosenbaum et al. (2010), with participants receiving 1 to 5 points on each question based on the "safety" of his or her answer (i.e. 5 points represented high safety and 1 represented a very unsafe response). Scores on each section were tabulated for section scores that were compared pre- and post-season.

Participants were also asked about their previous concussion history using Kaut et al.'s Head Injury Questionnaire (HIQ) (Kaut et al., 2003), which asks yes or no questions

regarding specific signs or symptoms of concussion which may have occurred within the last year. Finally, a commonly used symptom inventory – the Post-Concussion Scale (PCS), a 22-item scale designed to measure the severity of symptoms in the acute phase of a concussion with a 7-point Likert scale ("0" meaning did not experience the symptom, up to "6", meaning that the participant experienced that symptom severely), was used to describe symptoms experienced within the last year.

The post-season survey repeated the concussion symptom questions from the pre-season survey with the statement "within the last year" replaced by "in this varsity season". The Concussion Attitude Index (CAI) section of the RoCKAS-ST was also repeated in the second survey with the same change. Because there was no educational intervention given to the athletes during the season, the knowledge questions from the RoCKAS-ST were not repeated.

Analysis

Concussion knowledge was measured using responses on the first questionnaire (August 2015) from all participants. Percentage of correct responses was calculated for every knowledge question and compared to the mean for the questionnaire. Distractor questions were used on some sections of the education component of the questionnaire to ensure that participants were taking the completion of the questionnaire seriously. An example of a distractor question is "Weightlifting helps tone and/or build muscle", while an example of a true concussion education question is "People who have one concussion are more likely to have another concussion". The distractor questions were not included in the scoring but were checked and if these questions were not answered correctly, that questionnaire was not included in subsequent analysis.

Respondents who participated in both pre- and post-season were divided into "symptoms reported" and "no symptoms reported" categories. Data was tested for normality and a two-way repeated measures ANOVA with group as a factor was

performed to determine if their attitudes had changed over the course of the season and if this differed by group.

Results

At preseason, 87% of the eligible athletes completed the survey (N=96), with 28 freshman athletes and 68 returning (year 2-5) athletes participating. Eighty one percent of athletes who completed pre-season surveys completed the post-season survey (N=78). The decrease in responders was mainly attributable to lacrosse players who had completed their season, and the difficulty in reaching those athletes. Three athletes who suffered season-ending injuries early in the varsity season also did not complete the second questionnaire as they had not practiced or played their sport for the majority of the season. Based on correct answers to the distractor questions none of the questionnaires had to be excluded from the analysis.

Demographic Information

Concussion history for participants in part one (pre-season) of the study is provided in Table 2. Notably, over 25% of respondents reported a major fall, motor vehicle accident or hit to the head within the last year, and 43% of returning athletes and 32% of freshman athletes reported experiencing a headache during physical activity at least once in the last year. In both freshman and returning athletes, over 50% of respondents did not report their headache to coaches or medical personnel and continued to play. Ten percent of returning athletes reported a diagnosed concussion over the last year (prior to the 2015 season), while 14% of freshman athletes had been diagnosed. In both cases almost 20% of participants believed that they had experienced a concussion within the last year.

Table 2: Participant Concussion History at Pre-Season

Participants Total N=96		Returning Athletes N=68	Freshman Athletes N=28
Characteristic		**Yes, n (%)**	**Yes, n (%)**
Previous concussion education?		53 (78%)	15 (54%)
MVA, Hit to Head, Major Fall in last year?		18 (26%)	8 (29%)
Headache During Physical Activity		29 (43%)	9 (32%)
	Reported Headache	8 (28%)	4 (44%)
	Did Not Report Headache	21 (72%)	5 (56%)
Diagnosed With Concussion in Last Year		7 (10%)	4 (14%)
Think Had A Concussion in Last Year		13 (19%)	5 (18%)
Average number of diagnosed concussions (lifetime) - total group		0.87	0.75
Average number of diagnosed concussions (lifetime) - reported headache in last year group		1.79	1.62
Average number of believed concussions (lifetime) - total group		1.78	1.32
Average number of believed concussions (lifetime) - reported headache in last year group		2.69	2.31

For both freshman and returning athletes, the participants who experienced a concussion in the previous year reported a higher number of both diagnosed and believed concussions over their lifetimes. Returning athletes with a reported headache in the previous year believed that they had experienced an average of 2.69 concussions over their lifetime, with their freshman counterparts believing that they had experienced 2.31 concussions over their lifetimes.

Table 3 reports potential and reported concussions experienced by participants during the 2015 fall varsity season. The data comes from Part 2 of the study – questionnaires completed at the end of the fall season. A higher percentage of athletes reported receiving concussion education over the season, despite no formal concussion education being given to the teams. Of the 23 athletes who experienced symptoms that they believed could have been a result of a concussion, 43% chose not to report their symptoms, despite recognizing that they may have been a result of a concussion. A total of 10 athletes (13%) were diagnosed with a concussion over the 4 month season, while 15 (19%) believe that they suffered a concussion in the same period of time.

Table 4 illustrates the number of days athletes diagnosed with a concussion during the 2015 season were symptomatic, as well as the number of days of games/practices, and number of days of classes missed. Over the course of a 4 month season, an average of 15.2 days of games and practices were missed. Similarly, over a school term, an average of 11.7 days of school missed could account for more than 3 weeks of missed classes for a student. With a total of 187 symptomatic days, and 152 days of games and practices missed, there were few days during the fall varsity season that a soccer, hockey or lacrosse athlete was not missing playing time due to concussive symptoms.

Table 3: Participant Concussion Information at Post-Season

		Participants Total N=78
Characteristic		**Yes, n (%)**
Previous concussion education?		62 (79%)
MVA, Hit to Head, Major Fall in 2015 season?		25 (32%)
Symptoms that might have been from a concussion in 2015 season?		23 (29%)
	Reported Symptoms	13 (57%)
	Did Not Report Symptoms	10 (43%)
Diagnosed With Concussion in 2015 season		10 (13%)
Think Had A Concussion in 2015 season		15 (19%)
Average number of diagnosed concussions (lifetime) – total group		1.04
Average number of diagnosed concussions (lifetime) – reported symptom group		2.03
Average number of believed concussions (lifetime) – total group		1.76
Average number of believed concussions (lifetime) – reported headache group		2.85

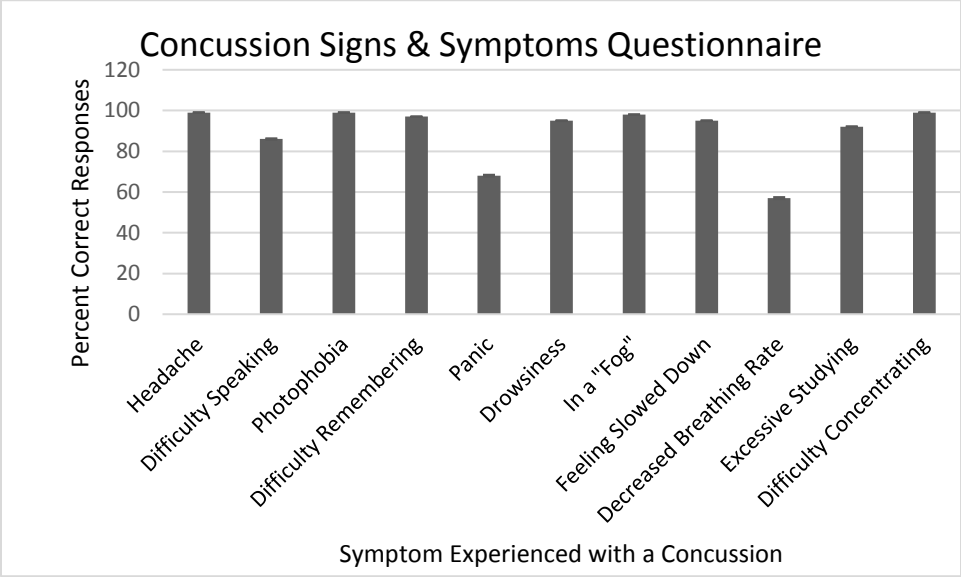
Table 4: Time Missed for Concussed Athletes During the 2015 Fall Season

	Concussed Athletes N = 10
Total # Days with symptoms	187
Average # Days with symptoms	18.7 Min = 3, Max = 60
Total # of games/practices missed	152
Average # of games/practices missed	15.2 Min = 0, Max = 40
Total # days of class missed	117
Average # days of class missed	11.7 Min = 0, Max = 40

Concussion Knowledge & Education at Baseline (Pre-Season)

With 71% of all athletes reporting having received concussion education prior to the 2015 varsity season, the RoCKAS-ST questionnaire knowledge and education questions showed a high level of concussion awareness. Participants showed the highest level of knowledge on symptoms of a concussion (Figure 3), with 91.7% of all questions answered correctly. Almost 100% of all participants recognized headache, photophobia, difficulty remembering, feeling "in a fog", difficulty concentrating, and dizziness as common sign and symptoms of a concussion.

Figure 3: Symptom Knowledge Questions - From ROCKAS-ST

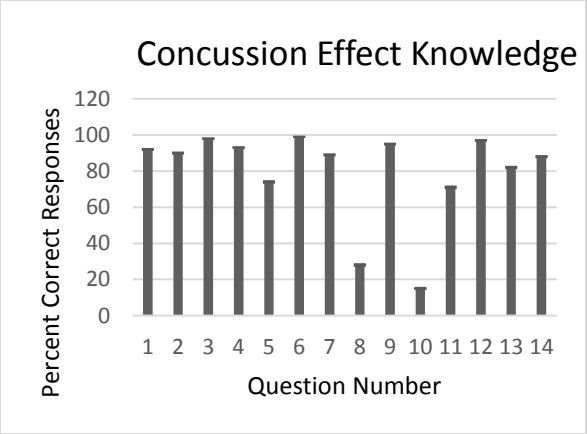


Participant knowledge of the effects of concussion was assessed using the RoCKAS-ST questionnaire. As there are four "distractor" questions within the questionnaire, only the 14 questions directly relating to concussion effect knowledge are presented in Figure 4, with the actual questions found in Table 5. The average percent correct for the concussion effect questions was 79%, showing a high level of concussion effect knowledge in the participant group. However, only 28% of participants knew that concussions are not typically shown on medical imaging (question 18), and only 15% knew that the majority of concussion symptoms are usually resolved in 10 days (question 10).

Table 5: Concussion Knowledge Questions

Q#	Concussion Effect Question
1	There is a possible risk of death if a second concussion occurs before the first one has healed
2	People who have had one concussion are more likely to have another concussion.
3	In order to be diagnosed with a concussion, you have to be knocked out.
4	A concussion can only occur if there is a direct hit to the head.
5	Being knocked unconscious always causes permanent damage to the brain.
6	Symptoms of a concussion can last for several weeks.
7	Sometimes a second concussion can help a person remember things that were forgotten after the first concussion.
8	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.
9	If you receive one concussion and you have never had a concussion before, you will become less intelligent.
10	After 10 days, symptoms of a concussion are usually completely gone.
11	After a concussion, people can forget who they are and not recognize others but be perfect in every other way.
12	Concussions can sometimes lead to emotional disruptions.
13	An athlete who gets knocked out after getting a concussion is experiencing a coma.
14	There is rarely a risk to long-term health and well-being from multiple concussions.

Figure 4: Concussion Effect Knowledge – Correct Responses



When comparing previously concussed individuals to those with no previous history of diagnosed concussion, previously concussed athletes demonstrated slightly better knowledge of the effects of concussions for all but questions 1, 11 and 12 but this was not statistically significant (See Figure 5 and Table 6).

Figure 5: Concussion Knowledge in Previously Concussed Individuals vs. No History of Concussion

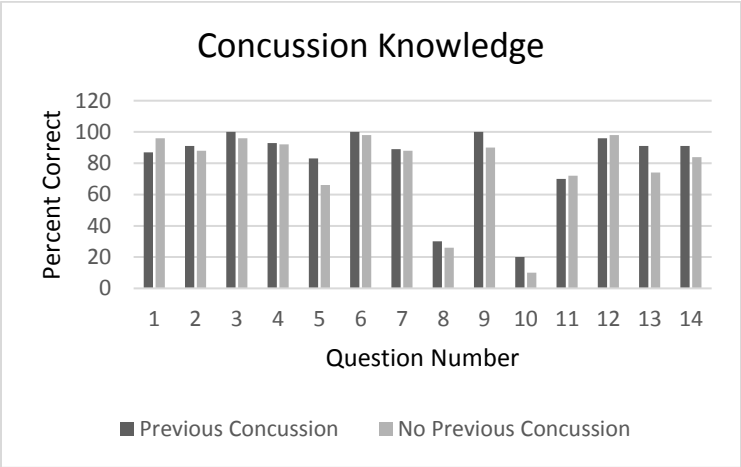


Table 6: Percent Correct Concussion Knowledge Questions - Previously Concussed vs. Non-Concussed Participants

	Question #	1	2	3	4	5	6	7	8	9	10	11	12	13	14
Percent Correct	Prev. Conc.	87	91	100	93	83	100	89	30	100	20	70	96	91	91
	No Prev. Conc.	96	88	96	92	66	98	88	26	90	10	72	98	74	84

Pre- and Post-Season Attitude Questionnaire Scores

The responses of the athletes who completed the post-season questionnaire (N=78) were compared with their pre-season responses. Scores for general attitude questions (Table 7) were summed (max. score =40), and those who reported experiencing symptoms that may have been from a concussion showed a slightly "less safe" overall score in all sections (pre = 29.65 SD=3.94, post = 29.78 SD=3.87) than those who did not report symptoms (pre = 31.84 SD=3.39, post = 30.56 SD=3.24). A trend toward interaction was found ($F(1,77) = 2.6$, $p=0.11$) between pre- and post-season general attitudes toward concussion.

The "Personal Attitude/Intention" section of Table 7 reflects responses to participants' personal beliefs about reporting their own concussive symptoms – i.e. consequences to the team, personal consequences, and confidence in ability to report signs and symptoms. Similar to questions about general attitudes toward reporting, participants showed a trend toward safe beliefs about concussion reporting, for both symptomatic

and asymptomatic athletes. With a maximum possible score of 75, asymptomatic athletes reported a pre-season score of 50.11 (SD=8.03) and a post season score of 48.25 (SD=6.15), while symptomatic athletes had a pre-season score of 44.65 (SD=8.13) and a post-season score of 45.17 (SD=8.90). Interestingly, those athletes who experienced concussion symptoms during the season showed less-safe scores than their asymptomatic peers both pre- and post-season, however, they showed a slightly higher (safer) score at the end of the season than on their pre-season score, while the asymptomatic athletes scored slightly less safely. This change was not significant ($F(1,77) = 1.92$, $p=0.17$), but showed a trend toward an improved (safer) attitude toward concussion reporting in those who had experienced symptoms.

For both symptomatic and asymptomatic athletes there was a decrease in the percent score for questions asking about personal attitudes and intentions when compared to general attitude questions. In the post-season, a mean score of 30.6/40 for asymptomatic athletes, and 29.8/40 for symptomatic athletes indicates and generally safer attitude toward concussion than do responses asking about their own behavioural intentions and attitudes toward reporting (asymptomatic post-season =48.4/75, symptomatic post-season =45.2/75), indicating that participants, while having a generally safe attitude toward concussion reporting, are less safe when asked about their personal intention and attitude toward their own symptoms. These are not statistically significant, however, may demonstrate a trend toward riskier or more unsafe behaviour in all athletes, with a more pronounced trend toward riskier reporting behaviour in those who experienced symptoms.

When asked which symptoms and the severity to which the symptoms would have to occur before reporting (Symptom Reporting Intention – Table 7), participants who experienced symptoms during the season showed slightly less safe attitudes toward symptom reporting than their asymptomatic teammates (asymptomatic athletes mean= 27.45 SD=5.91, symptomatic athletes mean= 26.48 SD=8.33). This could mean that either the symptom severity would need to be worse or more symptoms experienced

before those athletes chose to report to coaches or medical staff. The within-subjects interaction was not significant (F (1,77) = 0.01, p=0.92). Both groups reported the strongest intention to report vomiting or nausea as a symptom (91% of asymptomatic and 94% of symptomatic participants would report), while having the least intention of reporting a headache after an impact (49% of symptomatic and 48% of asymptomatic participants would not report a headache in the future).

Table 7: Concussion Attitude Questions - Comparisons at Pre- and Post-Season Responses in Symptomatic vs. Asymptomatic Participants

	General Attitude Questions (Max Score 40)				Personal Attitude/Intention (Max Score 75)				Symptom Reporting Intention (Max Score 40)			
	No Symptoms Reported		Symptoms Reported		No Symptoms Reported		Symptoms Reported		No Symptoms Reported		Symptoms Reported	
	Pre	Post	Pre	Post	Pre	Post	Pre	Post	Pre	Post	Pre	Post
Mean	31.84	30.56	29.65	29.78	50.11	48.25	44.65	45.17	27.87	27.45	27.04	26.48
SD	3.39	3.24	3.94	3.87	8.03	6.15	8.13	8.90	5.48	5.91	7.99	8.33

Table 8 reports athletes' personal experience during the season, with over 30% reporting experiencing dizziness and headaches after an impact and over 20% having problems studying or experiencing strange symptoms after an impact, or reporting having their "bell rung". Less than 5% of athletes reported loss of consciousness, vomiting, behaviour or memory changes after an impact.

Table 8: Symptoms Experienced by Participants During the 2015 Season

	Total N=78
Symptoms	**Yes, n (%)**
Dizziness after an impact to my body, head, or neck	26 (34%)
Saw stars after an impact	13 (17%)
Lost consciousness or blacked out after an impact	2 (3%)
Forgot what to do on the field/ice after an impact	1 (1%)
Had problems studying, concentrating or doing class work	18 (23%)
Had a headache at least once during the week after an impact	30 (39%)
Had my "bell rung"	21 (27%)
Vomited or felt nauseous after an impact	4 (5%)
Experienced strange symptoms after an impact but did not tell the coach or therapy staff (kept on playing/practicing)	18 (23%)
Continued to experience any strange symptoms after an	13 (17%)
Continued to experience any of these symptoms the day after a hit but did not tell a coach or Athletic Therapist	8 (10%)
Behaved differently than normal with friends or family	4 (5%)
Had difficulty making decisions or choices during every day	7 (9%)
Been more aggressive or emotional than normal	9 (12%)

When asked about their personal beliefs about concussion symptom reporting, 49% of participants stated an expectation that they would continue playing while experiencing a headache that resulted from a concussion. However, of those same respondents 96% agreed that coaches need to be extremely cautious when managing a concussed athletes' return to play, 100% thought that concussions were as or more important than other injuries, and only 8% felt that athletes have a responsibility to return to a game when concussed. Similarly, 92% were confident in their ability to recognize when they had signs or symptoms of a concussion, yet only 73% were confident in their ability to report signs and symptoms, even when they really want to play. A high percentage of athletes demonstrated intention to report nausea or dizziness after an impact at both pre- and post-season, however, approximately 50% expected that they would stop playing when experiencing a headache after an impact (Table 9).

Table 9: Reporting Intentions at Pre- and Post-Season

"I would stop playing and report my symptoms if I sustained an impact that caused me to…"	Pre-Season (N=96) %Yes	Post-Season (N=77) %Yes
See stars	75%	73%
Vomit or feel nauseous	91%	94%
Have a hard time remembering things	87%	81%
Have a hard time concentrating in class or on homework	78%	74%
Feel sensitive to light or noise	79%	77%
Have a headache	52%	51%
Experience dizziness or balance problems	87%	88%
Feel sleepy or "in a fog"	79%	75%

Discussion

Effective concussion management in athletes requires both the identification of signs and symptoms of concussion and proper assessment and follow-up treatment. Extensive research has been performed to create tools that will effectively and reliably identify symptoms and deficits in those who are tested, however, identifying those athletes who need to be removed from play and tested remains a challenge to sports-medicine professionals. To-date, one widely used method to improve concussion symptom reporting rates in athletes is education (Bramley et al., 2012; Echlin et al., 2010; Kaut et al., 2003; Kroshus, Baugh, Daneshvar, Nowinski, et al., 2014; Kroshus, Baugh, Daneshvar, & Viswanath, 2014; Kroshus, Daneshvar, et al., 2014; Kroshus, Garnett, Baugh, & Calzo, 2015). To this end, certain states have enacted laws requiring concussion education and sport governing bodies and institutions have mandated concussion education for all athletes (Kroshus, Baugh, Daneshvar, Nowinski, et al., 2014; P. McCrory et al., 2013).

The results of the present study indicate that varsity athletes have a high level of knowledge about the common signs and symptoms of concussion. Despite this apparent knowledge, a large percentage would choose not to report those symptoms over the course of a varsity season. These findings support previous research (Baker et al., 2013; Chrisman et al., 2013; Torres et al., 2013)(Chrisman, Torres, Baker, Baker), however concerning findings did arise. Notably, many participants in the current study did not

understand that the majority of concussions are not visible on imaging studies and that signs and symptoms often resolve in less than 10 days if managed properly. This lack of knowledge may be reflected in poor reporting behaviours if athletes do not realize how quickly symptoms could resolve or, if they relied on imaging to determine the existence or severity of their head injury.

With 78% of returning athletes and 54% of freshman athletes in the current study having received previous concussion education, and high scores by all athletes on concussion knowledge questions, athlete knowledge about the seriousness of concussion and its associated symptoms should reflect itself in high reporting rates. In fact, 43% of the 23 athletes who experienced a symptom that they believed may be a result of a concussion chose not to report to medical staff or coaches over the 4-month duration of the fall season. Thus, the high level of knowledge does not appear to relate to good symptom reporting rates.

The results of the present study are similar to other research that found a marked gap between awareness of the severity and knowledge of signs and symptoms of concussion and the decision to report. According to Bloodgood and colleagues, 84% of youth and 85% of parents had heard about concussion, and 70% of athletes thought concussion was a “critical issue” (Bloodgood et al., 2013). However, while 54% of athletes age 13-15 “strongly agreed” that concussion was a critical issue, only 34% of athletes age 16-18 strongly agreed. These findings are in contrast to those of the current study that found that 96% of participants agreed that coaches need to be cautious when returning an athlete to play after concussion, and 100% thought concussions were at least as serious as other injuries. Clearly the athletes in the present study understand the seriousness of concussion as an injury and believe that that those athletes with concussion need to be managed conservatively, yet this belief does not reflect their reporting behaviour and personal beliefs about their intention to report. Only 50% intend to report a headache and approximately 20% would report symptoms like seeing stars, difficulty

concentrating, sensitivity to light or noise or feeling like they are in a fog after a blow to the head or body.

In his study assessing basic concussion knowledge and attitudes of Irish Under 20 rugby players, Baker (2013) found that even after athlete education, 8% of athletes believed that being “knocked out” was required for a concussion diagnosis. On a more positive note, the same study found that 85% reported that they would inform someone if they thought that they had suffered a concussion, and 83% would do so for a teammate who they believed had suffered a concussion. This would indicate that the attitude of these athletes toward reporting was quite good, and that they understood the importance of reporting a concussion. Baker also found that there was a positive correlation between symptoms listed on the questionnaire and the number of previous concussions, leading the researchers to conclude that it is through previous concussion experience that players obtain concussion knowledge, not through organized education programs (Baker et al., 2013). This is similar to the findings of the current study, which found that 66% of all athletes reported receiving concussion education at the start of the season, while 79% reported having concussion education at the end of the season.

In the absence of a formal concussion education program during the season, it is likely that personal experience with concussion or seeing others suffer concussions over the course of the season increased the perceived knowledge of concussions by participants. Interestingly, there were two major incidents over the course of the season that may have influenced concussion knowledge among the participants – an athletics staff member left his position due to the long term effects of concussion, and a student-athlete suffered an assault which left visible signs of head injury – both of which led to increased discussion among athletes in the institution. These two occurrences, combined with the high number of diagnosed concussions on the varsity teams (20 amongst the 5 varsity teams studied) may have indirectly increased knowledge among all varsity athletes. These findings illustrate one of the critical issues involved in concussion education – namely that increased awareness of the seriousness of

concussions and the signs and symptoms involved, doesn't mean that athletes will disclose their injury.

Therefore, concussion education alone does not appear to be the solution to increasing reporting behaviour in collegiate athletes. This suggests there are a number of factors involved in the decision for an athlete to report his or her symptoms, rather than education alone.

A number of studies have demonstrated that athletes continue to play while experiencing symptoms of concussion (Baker et al., 2013; Chrisman et al., 2013; Hollis et al., 2012; Meehan III et al., 2013; J. K. Register-Mihalik et al., 2013). Findings by Kaut et al. (2003) indicated that 28.2% of all athletes continued to play while dizzy, and specifically, 17.7% of male soccer players failed to report the dizziness to medical personnel and continued to play. The study also found that 30.4% of all athletes played with a headache after being hit, and in particular, that 26.7% of male soccer players did so. Authors of a study investigating numbers of symptoms reported over time in concussed high school and collegiate athletes noted that athletes may minimize the effects of their concussion in order to be quickly cleared to play (M R Lovell et al., 2002). The present study found similar rates of athletes playing with a headache that may have been a result of a concussion with 36% of participants failing to report this symptom. In fact, although over 20% of athletes reported experiencing any one or all of dizziness, difficulties studying, headaches, strange signs and symptoms and having their "bell rung" after an impact, with only 10 athletes reporting symptoms to medical staff over the season, clearly a number of athletes did not report. Interestingly, most athletes did not report experiencing obvious signs of concussion like loss of consciousness, vomiting, and behaviour changes on or off the field during the 2015 season. Those signs would have been noticeable to others and may have forced reporting by the injured athlete. Therefore, if the obvious signs of concussion are not the most commonly experienced by athletes, it necessitates self-disclosure by the athlete to start the assessment process because others will not recognize that they are concussed.

My research demonstrates a generally safe attitude toward concussion reporting for all athletes in both pre- and post-season measures, however, those who experienced symptoms of a concussion over the course of the season showed riskier attitudes at both pre- and post-season than their asymptomatic peers. Interestingly, those who reported symptoms of a concussion during the season did show a very small increase in score from pre- to post-season, suggesting a slightly safer attitude toward reporting. Unfortunately, all athletes reported riskier behavioural intentions when it came to personal attitudes toward reporting intention and behaviour. It would appear that while the participants understood the importance of athletes in general reporting concussive signs and symptoms, they did not hold the same expectation of safe behaviours for themselves. This contrasts with the findings of Kroshus et al. who found that athletes tended to believe that they held safer reporting practices than other athletes (Kroshus, Kubzansky, Goldman, & Austin, 2014a). Kroshus hypothesized that those athletes who identify more strongly with the athlete role have less safe reporting intention and behaviour (Kroshus, Kubzansky, et al., 2014a). So it is possible that the athletes in the current study have a stronger athlete identity and thus have less safe reporting behaviours for themselves when compared to their general attitude toward reporting. Similar to the general attitude questions, those who experienced concussion symptoms over the course of the season displayed riskier intentions than their asymptomatic peers, but their scores increased (became safer) in the post-season survey, possibly indicating increased intention to report future symptoms, based on their experience over the course of the season.

For the 10 athletes who experienced a diagnosed concussion over the season, an average of over 15 days or practice/play and almost 12 days of school was missed while experiencing symptoms. For student-athletes who have a very short season (2 months for soccer and lacrosse players) and a 12-week school term, missing any time from academics or sport could have a significant effect on both academic and sport performance.

Limitations

Because the study was limited to a convenience sample of one mid-sized Canadian institution, and athletes from only 3 sports were included in the study, generalization of the results to the larger population of CIS universities should be done with caution. The response rate for the post-season questionnaires was very good (80%), but only represents athletes in contact and collision team sports, and does not reflect a cohort of athletes in all types of sports. In addition, the use of retrospective self-report scales yields results based on memory of events, which may not accurately reflect all symptoms experienced by the participants. While recall bias is a possible issue with retrospective studies (Coughlin, 1990), this study also looks at knowledge and reporting intention as well as behaviour; so it is expected that the results accurately reflect participants' beliefs regarding concussion reporting.

Future research should expand to more institutions and increase the number of sports studied to include individual sport athletes, and those in non-contact as well as contact/collision sports. The use of questionnaire and survey did not allow the participant to expand on his or her responses or allow for other reasons for non-disclosure of symptoms to be taken into account. It would be beneficial for future studies to investigate other factors involved in non-reporting of concussion signs and symptoms, and reasons why athletes choose to report utilizing qualitative methods.

Conclusions

This study highlights that a high level of concussion education does not lead to increased reporting intention or behaviour in varsity athletes. While athletes understand that concussion is a serious injury, and expect that others will report their signs and symptoms, they do not necessarily have those expectations of themselves. Those with a history of concussions have a generally less-safe intention to report future concussions than their peers with no history of concussion, despite a high level of understanding of both the signs and symptoms and consequences of concussion. In a short 4-month fall season, a significant amount of academic and practice/game time was lost due to concussion in athletes who reported symptoms to medical staff. Increased reporting behaviours would lead to even more lost time, so institutions need to ensure effective return-to-learn and return-to-play protocols are in effect in order to ensure safe return after concussion. Future research should focus on additional factors or changes to concussion education that will encourage improved symptom reporting among athletes.

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Chapter 3 - Manuscript 2:

A Mixed- Methods Approach to the Exploration of Concussion Under-Reporting in Varsity Athletes

Abstract

Background & Purpose: Despite improved awareness of the signs and symptoms of concussion and the potential seriousness of mismanaged concussions, under-reporting of concussions remains a serious issue. Because the signs and symptoms are often invisible, varsity athletes must choose whether or not to reveal their concussions to medical staff. Many factors are involved in the decision-making process that athletes undergo in deciding whether or not to report. The purpose of this study was to explore factors influencing reporting behaviours in varsity athletes.

Methods: A sequential mixed-methods design with a quantitative priority was utilized. Pre- and post-season surveys were administered to varsity hockey, soccer, and lacrosse athletes at a mid-sized Canadian university. Concussion knowledge was measured at pre-season, and pre- and post-season intentions, attitudes and behaviours were measured using the "Rosenbaum Concussion Knowledge and Attitudes Survey- Student Version (RoCKAS-ST), "Head Injury Questionnaire", and "Post-Concussion Scale" (PCS). At post-season, participants were divided into "Asymptomatic", "Symptoms Not Reported" and "Symptoms Reported" groups. A two-way repeated measures ANOVA was used to measure attitude changes from pre- to post-season. At the conclusion of the season, participants were interviewed using semi-structured interviews to explore reasons for not reporting, and their responses recorded and transcribed. Transcripts were analyzed by three investigators and codes were consolidated and collapsed into themes.

Results: Seventy-eight completed the post-season survey and 29% of participants (n=23) had experienced symptoms that they felt may have been from a concussion. Of the group that experienced symptoms, 43% failed to report their symptoms to staff. Knowledge of concussion signs and symptoms was high, with 91.7% of all knowledge and education questions answered correctly. The "Symptoms Reported" group demonstrated an increase in confidence to report their symptoms from pre- to post-season, while the "Symptoms Not Reported" group continued to demonstrate unsafe

reporting intentions from pre- to post-season. All groups were found to have safe attitudes towards reporting by other athletes, even if their personal intentions were unsafe.

Nine athletes were interviewed and themes of “Knowledge”, “Influences to Non-Reporting” and “Threshold to Report” emerged. All participants reflected a high knowledge of signs and symptoms, however, the influence of other factors played a larger role in their decision to report than did their understanding of the effects of concussion.

Conclusion: Athletes are aware of the seriousness and effects of concussion and must balance this knowledge with inter- and intra-personal factors that often play a larger role in their decision to not report. Future educational interventions which address social and personal barriers to reporting may be more effective at improving reporting behavior than only providing education regarding signs and symptoms and consequences of concussion.

Introduction

Managing sport-induced concussion is an increasing challenge for coaches, athletes, and medical professionals at all levels of sport participation. Researchers have estimated that between 1.6 and 3.8 million sport-related concussions occur in the United States every year (Langlois et al., 2006); however, rates of underreporting are estimated to be as high as 60% (Kaut et al., 2003). The potential short and long-term outcomes of improperly managed concussions on cognition, impairments to activities of daily living, and catastrophic consequences like Second Impact Syndrome or neural (brain) degeneration, means that detection and management at the early stages are imperative for positive outcomes.

Medical staff need to be aware of causes, signs and symptoms, and effective on-field and clinical assessment tools for concussion. Although symptoms may present immediately after injury, many players have delayed onset (Fazio et al., 2007). Adverse outcomes are more frequent when concussions are not identified and athletes are allowed to continue playing, or when athletes identified with a concussion are allowed to return too early, before they have fully recovered. For collegiate-age athletes, symptoms are especially pronounced in the days immediately following injury and can significantly affect their learning and academic performance (Chinn & Porter, 2013). In addition, lack of reporting of concussive symptoms may lead to not receiving proper treatment or academic accommodations, and may increase risk of catastrophic consequences. Previous research has attempted to identify reasons for non-reporting or numbers of concussions experienced over the course of a career, but few have allowed athletes to discuss reasons why they choose not to report (Gilbert, 2014; T. Llewellyn, Burdette, Joyner, & Buckley, 2014; T. A. Llewellyn, 2012). There are many factors that might influence non-reporting behaviour in an athlete. My study will explore what these factors are and how they intersect to limit symptom reporting behaviours in collegiate athletes.

A number of post-season retrospective studies have been performed on athletes; asking about symptoms experienced during the season, attitudes towards reporting, and reporting behaviour. Unlike prospective studies, retrospective research often demonstrates the true number of concussion symptoms experienced by collegiate athletes because they do not have to be concerned about being removed from their sport if they reveal symptoms after the fact (post-season) (J Scott Delaney et al., 2000; J. S. Delaney et al., 2002). One study of former National Collegiate Athletic Association (NCAA) athletes found that 49.7% reported suffering a potential concussion during their collegiate career (T. Llewellyn et al., 2014); however, the study did not investigate the decision-making process related to reporting or non-reporting of concussive symptoms. Earlier studies reported that athletes with a previous concussion would be highly unlikely to report symptoms of a subsequent concussion (Mansell et al., 2010), and that athlete attitude toward concussion reporting was as important as concussion education, and could in fact create a major barrier to the proper care of concussed athletes (Rivara et al., 2014). Considerations such as scholarships, peer acceptance, and support of coaches add to the "self-identity" of collegiate athletes which manifests itself in a strong desire to participate in practices and games (J. K. Register-Mihalik et al., 2013).

Barriers to concussion reporting, including the desire to compete, level of education of the signs and symptoms of concussion, and history of concussion have been explored through both quantitative and qualitative methodology. Use of questionnaires and surveys to quantify symptoms experienced during a season or career, or to determine concussion knowledge among athletes, can give useful information to researchers and clinicians to improve concussion recognition and education. Qualitative research, including interviews and focus groups with athletes, gives insight into the attitudes and reporting intentions of these individuals toward injury, and more specifically, to concussion. One of the major themes that emerges in both quantitative and qualitative studies is that of athlete understanding and education of the signs, symptoms, and severity of concussion (Echlin et al., 2010; Kaut et al., 2003; Kroshus, Daneshvar, et al., 2014; Miyashita, Timpson, Frye, & Gloeckner, 2013; J. K. Register-Mihalik et al., 2013;

Johna K Register-Mihalik, Laura A Linnan, et al., 2013b). Understanding is a significant factor in detection of head injury in athletes, because if athletes do not understand that their symptoms are those of a concussion, or they do not believe that concussion is a serious injury, athletes are less likely to report. More recent studies suggest that athlete knowledge about signs and symptoms improves with the introduction of education systems within teams and sport organizations (Kerr et al., 2014; Kurowski, Pomerantz, Schaiper, & Gittelman, 2014; O'Connell & Molloy, 2015; Johna K Register-Mihalik, Kevin M Guskiewicz, et al., 2013), however, the number of athletes who continue to play while experiencing symptoms remains high. This is evident in a study by Rivara in 2014, who investigated the number of high school athletes who played with concussive symptoms and the effect of a mandatory concussion reporting system. He found that 69% of high school athletes in the study reported playing with symptoms, and that among concussed athletes, 40% played while symptomatic without their coach knowing that they were concussed. These athletes continued to play despite having to sign a statement at the beginning of the season stating that they would disclose all symptoms to the coach (Rivara et al., 2014). Rivara's findings that athletes would continue to play while symptomatic were consistent between different sports, including girls' soccer and boy's football, and found that only 1/3 of athletes who experienced symptoms consistent with a concussion received a concussion diagnosis. While concussion education is an important factor in having coaches, parents, and athletes on-board with symptom reporting and concussion diagnosis, it would appear that there are still other reasons why athletes are not reporting their symptoms to medical personnel.

In 2013, Chrisman and colleagues concluded high school football and soccer players know a great deal about concussion despite other studies suggesting athletes do not report symptoms of concussion due to a lack of knowledge (Kaut et al., 2003; Sye et al., 2006). However, even with this apparent knowledge, focus groups of athletes indicated that they still would not report their injury even when presented with a scenario of a collision that caused symptoms (Chrisman et al., 2013). Mansell and colleagues took a different approach – they looked to evaluate the association between an athlete

experiencing a previous concussion and reporting signs and symptoms after a subsequent hit (Mansell et al., 2010). They found that 59% of athletes without a previous concussion reported symptoms after a hit to the head, compared to 80% of previously concussed athletes who reported symptoms. All of these instances were in non-documented concussions, indicating that athletes with a history of concussion (who likely had knowledge of concussion as a result of their previously diagnosed concussion) were choosing not to report their new symptoms, even though they were aware of the common signs and symptoms, and likely, the consequences. Athletes in Chrisman's study, while discussing knowledge of concussion symptoms and the desire to keep playing, also commented on the notion that, as an athlete, you are supposed to play injured (Chrisman et al., 2013). The participants in the study did not feel that it was acceptable to leave a game for non-specific symptoms (those associated with a concussion), and remarked that even though they knew that what they were feeling were symptoms of a concussion, they did not want to look weak in front of coaches or teammates. Similar findings are reported in a 2013 study by Torres and colleagues, which found that 43% of collegiate athletes with a history of concussion had knowingly hidden symptoms in order to stay in a game, and 22% of the athletes reported that they would be unlikely to report a concussion to a coach or a trainer (Torres et al., 2013).

The number of athletes playing university-level sport is much lower in Canada than the United States due to the smaller population, however, with over 15,000 ("About CIS", n.d.) student-athletes playing university sport in Canada, the potential for a large number of student-athletes to be affected by concussion is very high. Many of the qualitative studies undertaken on reporting of concussion in athletes have illustrated 3 major themes – athlete knowledge and understanding of concussion, athlete attitude toward concussion reporting (and wanting to play), and the "culture of risk" that athletes are living in and identify with even while they are injured (Chrisman et al., 2013; Kroshus & Kroshus, 2012). However, no research to date has explored these themes together and given athletes an opportunity to explore these concepts more in-depth. As previously noted, both quantitative and qualitative research methodologies have been

extensively used to investigate concussion symptom knowledge, concussion history, and barriers toward concussion reporting. Few studies have utilized mixed methods to allow for the in-depth follow up of attitude and reporting intention and behaviours subsequent to the quantitative data collection. My study examines concussion symptom reporting behaviour and attitudes in varsity athletes in a member institution of the Ontario University Athletics (OUA) conference of the Canadian Interuniversity Sport league (CIS). Combining the use of pre- and post-season questionnaires and post-season interviews to examine concussion reporting intention and behaviours, current gaps in knowledge can be filled. This research methodology allows the researcher to explore reasons why athletes decide to either report or not report concussive symptoms during a varsity sport season.

Methods

A mixed methods design was utilized as it allows for the exploration and explanation of the research question. The quantitative (survey) data was prioritized (QUAN → qual) and used to inform the qualitative (interview) phase. The pre- and post-season surveys provided the primary data and allowed for purposeful sampling for the qualitative phase. The interviews were used to explore and provide meaning to the survey results.

Participants

Men's and women's varsity soccer and hockey, and women's lacrosse players at a mid-sized Canadian university participated in this study. These athletes compete in the Ontario University Athletics (OUA) conference within the Canadian Interuniversity Sport organization. Athletes between the ages of 17 and 25, not currently experiencing the symptoms of a concussion, and who were able to complete the written questionnaire were included in the study. Participating athletes completed written surveys in August 2015 and again in November 2015, at the conclusion of the fall varsity season. Soccer and lacrosse teams completed the initial survey during a mandatory "Varsity 101" session, during which athletes are given instruction and education regarding their participation on a varsity team, while the hockey athletes completed the survey prior to

baseline concussion testing. After the final game of the fall season, participants were asked to complete a follow-up survey during a team meeting. The men's hockey team completed their second survey in December 2015, after their final game of the first half of the season.

Questionnaires

At pre-season, participants were given a questionnaire that measured knowledge, attitude and intention toward concussion reporting. The questionnaire included "Rosenbaum Concussion Knowledge and Attitudes Survey-Student Version" (RoCKAS-ST) (Rosenbaum & Arnett, 2010) and the attitudes and perceived consequences of reporting sections from Kroshus et al.'s studies on collegiate athletes (Kroshus, Garnett, Hawrilenko, Baugh, & Calzo, 2015; Kroshus, Kubzansky, et al., 2014a). The RoCKAS-ST has been shown to have high face validity and adequate reliability (Rosenbaum & Arnett, 2010) and choosing to play while experiencing a symptom of a concussion is considered to be a "face valid proxy for symptom reporting intention as it reflects the individual's overall appraisal of their likelihood of engaging in the opposite behaviour of symptom reporting" (Kroshus, 2014). Participants were also asked about their previous concussion history using the Head Injury Questionnaire (HIQ) (Kaut et al., 2003), which asks yes or no questions regarding specific signs or symptoms of concussion which may have occurred within the last year. Finally, a commonly used symptom inventory – the Post-Concussion Scale (PCS) (Mark R Lovell & Collins, 1998), a 22-item scale designed to measure the severity of symptoms in the acute phase of a concussion was used with a 7-point Likert scale ("0" meaning did not experience the symptom, up to "6", meaning that the participant experienced that symptom severely), was used to describe symptoms experienced within the last year.

Post-season, only the attitude and behavioural intention questions (Concussion Attitude Index – CAI) from the RoCKAS-ST, as well as the HIQ and PCS were administered. Knowledge questions were not repeated because no formal education intervention was administered over the course of the study, therefore education levels were not expected to change. Wording on the PCS and CAI was changed from "within

the last year" on the pre-season questionnaire to "in this varsity season" on the post-season version. Scoring was performed as outlined by Rosenbaum et al (2010), with participants receiving 1 to 5 points on each question based on the "safety" of his or her answer (i.e. 5 points represented high safety and 1 represented a very unsafe response). Scores on each section were tabulated for section scores that were compared pre- and post-season.

Questionnaires were coded by research assistants and participants remained anonymous to the principle researcher due to her role at varsity Athletic Therapist for varsity teams.

Analysis

Concussion symptom knowledge (level of education) was measured using responses on the first questionnaire administered in August 2015 (N=96). Percentage of correct responses was calculated for every knowledge question and compared to the mean for the questionnaire.

Participants who participated in both pre- and post-season (N=78) were divided into "symptomatic" and "asymptomatic" categories. Further, those who reported symptoms on the final questionnaire were divided into 2 subcategories – those who reported symptoms (symptoms reported) to medical staff and those who did not (no symptoms reported). Data was tested for normality and a two-way repeated measures ANOVA with group as a factor was performed to determine if their attitudes had changed over the course of the season and if this differed by group.

Interviews

A semi-structured interview guide was developed based on a review of the literature, the research question, as well as consideration of the survey questions, in an effort to understand the athlete's description. The semi-structured script allowed for open-ended questions and discussion around certain responses and themes that emerged over the course of the interview. It also allowed participants to add any ideas that they felt were important to the discussion.

Coded questionnaires were analyzed by the principle investigator, prospective participants identified, and codes given to research assistants who then decoded the participant identity and emailed the individual to recruit for the interview portion. Interview participants were selected based on responses in the pre- and post-season questionnaires, with a focus on recruiting participants who reported concussive symptoms to medical staff, and those who had not reported. Participants who had not experienced symptoms of a concussion during the season were excluded. Upon agreeing to an interview, questionnaires belonging to the selected participants were decoded for the primary investigator, and the identity of the participant was revealed and an interview scheduled. Four participants who reported concussion symptoms and had reported them to medical personnel over the course of the season and five who had experienced symptoms but had not reported them to staff were recruited to participate in the interview phase.

Face-to-face interviews were conducted in December 2015 and January 2016 by the primary investigator. Participants were asked about their history of injuries, particularly concussions, and discussion emerged around reporting intention and previous behaviours around reporting, and return to play after concussion. Interviews ranged from 50 minutes to 75 minutes in length and all ended with an opportunity for participants to add any thoughts or ideas that they had regarding concussions or injury that they felt were not fully addressed or explored during the formal interview.

All interviews were audio recorded and professionally transcribed. Transcripts were independently coded by the primary investigator as well as 2 others. The primary investigator coded all nine transcripts, and developed an in-vivo coding scheme based on common ideas or categories. Two other researchers each coded three questionnaires, and all researchers met to describe and define the codes. Discussion of the codes between researchers ensured common definitions and descriptions of codes and validated the codes prior to categorization and creation of themes. The researchers

subsequently met to consolidate and discuss common categories and collapse them into emergent themes.

Details that would allow athlete identification have been omitted, and while all participants have been given a code, specific quotes that illustrate key findings have been de-identified to ensure anonymity. Institutional review board approval was received from the University of Ontario Institute of Technology (UOIT), and all participants provided informed written consent prior to participation.

Results

Survey (Quantitative) Phase

Ninety-six participants completed the pre-season questionnaire, and 78 completed the post-season version, for a pre- to post-season retention rate of 81%. When asked about receiving concussion education, 78% of returning athletes and 54% of freshman athletes reported having received education (71% of all athletes). This number increased to 79% of participants in the post-season questionnaire, in the absence of formal concussion education during the season. Table 10 presents pre-season participant information.

Table 10: Participant Concussion History at Pre-Season

Participants Total N=96		**Returning Athletes N=68**	**Freshman Athletes N=28**
Characteristic		**Yes, n (%)**	**Yes, n (%)**
Previous concussion education?		53 (78%)	15 (54%)
MVA, Hit to Head, Major Fall in last year?		18 (26%)	8 (29%)
Headache During Physical Activity		29 (43%)	9 (32%)
	Reported Headache	8 (28%)	4 (44%)
	Did Not Report Headache	21 (72%)	5 (56%)
Diagnosed With Concussion in Last Year		7 (10%)	4 (14%)
Think Had A Concussion in Last Year		13 (19%)	5 (18%)

Knowledge of Signs and Symptoms of Concussion

The education sections of the RoCKAS-ST reflected a high level of concussion knowledge on signs and symptoms of a concussion, with 91.7% of all questions answered correctly.

Almost 100% of participants recognized headache (99%), photophobia (99%), difficulty remembering 97%), feeling “in a fog” (98%), difficulty concentrating (99%), and dizziness (98%) as common signs and symptoms of a concussion. Knowledge of the effects of concussion was also high, with 79% of participants responding correctly to questions referring to the effect of concussions (e.g. “In order to be diagnosed with a concussion, you have to be knocked out”). Previously concussed athletes demonstrated slightly better knowledge of the effects of concussions compared to those with no prior history, however, this was not statistically significant.

Post-Season Participant Information

The characteristics of the 78 participants who completed the post-season survey are reported in Table 11. Of the 23 athletes who reported experiencing symptoms that could have been a result of a concussion over the 2015 season, 43% (n=10) did not report them to staff.

Table 11: Characteristics of Participants in the 2015 Season

Participants (N=78)		
Characteristic		**Yes, n (%)**
Previous concussion education?		62 (79%)
MVA, Hit to Head, Major Fall in 2015 season?		25 (32%)
Symptoms that might have been from a concussion in 2015 season?		23 (29%)
	Reported Symptoms	13 (57%)
	Did Not Report Symptoms	10 (43%)
Diagnosed With Concussion in 2015 season		10 (13%)
Think Had A Concussion in 2015 season		15 (19%)

Participant Attitudes Toward Reporting

Table 12 reports personal beliefs and attitudes toward reporting a concussion in three groups - those who reported experiencing symptoms (symptoms reported), those who had symptoms but did not report (non-report), and those who did not experience symptoms (asymptomatic) during the season. There was no change in attitude at post season for the symptomatic and symptoms-reported groups when asked about team performance. However, the symptoms reported group displayed an increased belief at

post-season that their teammates would think less of them if they reported, while the other groups remained unchanged. All groups showed a drop in agreement (a less safe attitude) on the beliefs that the sooner they report, the sooner they will be back at full strength, and continuing to play with a headache. However, the group that reported their symptoms demonstrated a marked increase in their confidence in their ability to recognize symptoms (31% pre-season to 62% post-season). This group was also the only group that became more confident in their ability to report symptoms from pre- to post-season.

In the group that experienced symptoms but did not report, 100% of participants believed at both pre and post-season that they would not be able to return to play when they thought they were ready, and 80% believed that they would lose their spot in the lineup. Interestingly, this group became safer in their belief about being held out of a game if the symptoms were not from a concussion (100% pre-season, 80% post-season), while the symptoms reported and asymptomatic groups became less safe. The not-reported group also had a 10% drop in intention to report a teammate's concussion at the post-season measure, while the other groups remained unchanged. The symptoms reported group showed a large change (8-23%) from pre- to post-season in the belief that their teammates would think less of them if they reported their symptoms.

Participant Experiences During the 2015 Fall Season

When asked about symptoms experienced as a result of an impact over the 2015 season, over 20% of the 78 participants reported experiencing dizziness, problems studying/concentrating, headache, having their "bell rung", and experiencing strange symptoms but continuing to play or practice (Table 13). Less than 5% of participants reported experiencing a loss of consciousness (3%), forgetting what to do on the field of play (1%), and vomiting (5%). Seventeen percent of participants reported playing after experiencing ongoing symptoms after an impact, and 10% reported symptoms the day after a hit and not reporting them.

Table 12: Personal Attitudes/Beliefs Toward Concussion Reporting – (Section 5: Post-Season Questionnaire)

	Number (n), and (%) Agreeing					
	Asymptomatic Group (N=55)		Symptoms Not Reported Group (N=10)		Symptoms Reported Group (N=13)	
Question	**Pre-Season**	**Post-Season**	**Pre-Season**	**Post-Season**	**Pre-Season**	**Post-Season**
If I report what I suspect might be a concussion, I will hurt my team's performance	14(25)	15(27)	4(40)	3(30)	3(23)	3(23)
If I report what I think might be a concussion, I will not be allowed to start playing or practicing when I think I'm ready	35(64)	29(53)	10(100)	10(100)	9(69)	10(77)
If I report what I suspect might be a concussion, I will lose my spot in the lineup.	24(44)	22(40)	8(80)	8(80)	6(46)	6(46)
If I report what I suspect might be a concussion, my teammates will think less of me	9(16)	9(16)	1(10)	1(10)	1(8)	3(23)
The sooner I report a concussion, the sooner I'll be back at full strength	45(82)	42(76)	6(60)	5(50)	11(85)	7(54)
If I report what I suspect might be a concussion, I will be held out of an upcoming game even if it is *not* a concussion	28(51)	30(55)	10(100)	8(80)	3(23)	6(46)
If I report what I suspect might be a concussion, my teammates will think I made the right decision.	31(56)	23(42)	4(40)	6(60)	4(31)	6(46)
If I report what I suspect might be a concussion, I will be better off in the long run	52(95)	45(82)	9(90)	9(90)	12(92)	10(77)
I am confident in my ability to recognize when I have symptoms of a concussion	37(67)	37(67)	8(80)	7(70)	4(31)	8(62)
I am confident in my ability to report symptoms of a concussion, even when I really want to keep playing	30(55)	24(44)	4(40)	3(30)	2(15)	6(46)
I am confident in my ability to report symptoms of a concussion, even when I think my teammates want me to play	26(47)	25(45)	4(40)	4(40)	4(31)	6(46)
I am confident in my ability to report symptoms of a concussion, even if I don't think they are that bad	21(38)	15(27)	3(30)	2(20)	2(15)	4(31)
I am confident in my ability to report specific symptoms, even if I am not sure that it is actually a concussion	26(47)	16(29)	3(30)	2(20)	1(8)	5(38)
I would continue playing a sport while also having a headache resulting from a concussion	19(35)	18(33)	9(90)	6(60)	5(38)	3(23)
I would tell the therapist if I thought a teammate had a concussion	17(31)	17(31)	3(30)	2(20)	2(15)	2(15)

Table 13: Experiences of Participants Following an Impact During the 2015 Fall Season (Section 3: Post-Season Questionnaire)

Question (N=78)	Yes, n (%)
Dizziness after an impact to my body, head, or neck	26(34%)
Saw stars after an impact	13(17%)
Lost consciousness or blacked out after an impact	2(3%)
Forgot what to do on the field/ice after an impact	1(1%)
Had problems studying, concentrating or doing class work after an impact	18(23%)
Had a headache at least once during the week after an impact	30(39%)
Had my "bell rung"	21(27%)
Vomited or felt nauseous after an impact	4(5%)
Experienced strange symptoms after an impact but did not tell the coach or therapy staff (kept on playing/practicing)	18(23%)
Continued to experience any strange symptoms after an impact and kept on playing	13(17%)
Continued to experience any of these symptoms the day after a hit but did not tell a coach or Athletic Therapist	8(10%)
Behaved differently than normal with friends or family	4(5%)
Had difficulty making decisions or choices during every day activities	7(9%)
Been more aggressive or emotional than normal	9(12%)

Participants were asked at pre- and post-season what concussion symptoms they would report to staff if they experienced them over the course of the season (Table 14). There were no significant changes in attitudes.

Table 14: Personal Intentions to Report Symptoms (Section 6: Post-Season Questionnaire)

"I would stop playing and report my symptoms if I sustained an impact that caused me to…"	Pre-Season (N=96) %Yes	Post-Season (N=78) %Yes
See stars	75%	73%
Vomit or feel nauseous	91%	94%
Have a hard time remembering things	87%	81%
Have a hard time concentrating in class or on homework	78%	74%
Feel sensitive to light or noise	79%	77%
Have a headache	52%	51%
Experience dizziness or balance problems	87%	88%
Feel sleepy or "in a fog"	79%	75%

Qualitative Phase

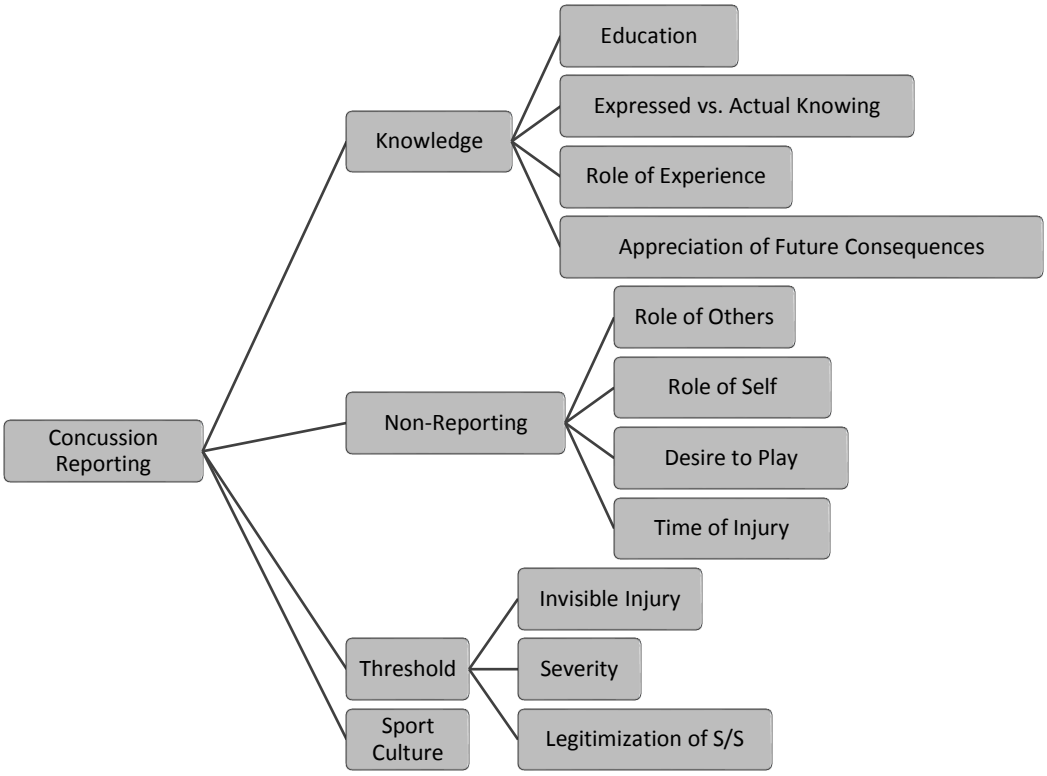
Nine athletes were recruited to participate in the interview phase and all agreed. A total of 6 females and 3 males ranging in age from 18 to 25 years (average 20.6 years); including 3 freshmen, 1 second year, 2 third year and 3 fourth year athletes, and representing each team involved in the study. The majority (89%) reported playing their sport for over 10 years, with men's hockey players reporting playing their sport for the longest time (21.5 years average) and lacrosse players for the least (5 years average). Five participants had experienced symptoms over the season but did not report them, while 4 reported their symptoms to medical staff (Table 15).

Table 15: Interview Participant Demographics

Sex	Years Playing	Sport	Reported S/S?
F	5	Lax	Y
F	17	Hockey	N
F	12	Hockey	N
F	16	Soccer	Y
F	10	Soccer	N
F	17	Soccer	N
M	21	Hockey	Y
M	22	Hockey	N
M	15	Soccer	Y
	Average = 15		

Four themes emerged from data that summarized characteristics that influenced athletes' reporting of concussive signs and symptoms. Knowledge of the signs and symptoms of concussion, influences to non-reporting influences, sport culture, and threshold before reporting occurs all played a role in the decision making process to report symptoms. Further, these themes could be sub-divided into categories (Figure 6).

Figure 6: Key Themes Influencing Concussion Reporting



Knowledge of Signs and Symptoms

Participants reported a high level of awareness of concussion signs and symptoms, and had been provided concussion education, in some form, over the course of their athletic career. This education may have come in the form of formal, structured sessions or through personal experience. This knowledge helped to inform their decision making process to report future concussive symptoms. However, their actual knowledge and appreciation of the severity and long term consequences of concussion also influenced their reporting intentions and behaviours.

Education

All participants described a high level of symptom knowledge and education in both their survey data and interviews, however, this did not necessarily reflect their intention or actual behaviour in reporting their symptoms. For the purpose of this paper, the knowledge of signs, symptoms, and effects of concussion is referred to as “expressed

knowing". The results of the quantitative survey data suggested a high level of expressed knowing, indicating that participants know, on a cognitive level, what causes a concussion and subsequent signs and symptoms. This was confirmed in the interview phase, as participants would spontaneously note common signs, symptoms, and mechanisms of concussion. They also were highly knowledgeable about the potential consequences of playing while concussed; many participants commented on long term memory or concentration problems that they or others had experienced, as well as mentioning other athletes who had died as a result of their concussion(s). One participant stated:

> "There are a bunch of NFL players who have died early at 30 because of these injuries and the illness that comes up because of it. Also because I know it can cause Alzheimer's, dementia and all that stuff, I do know it is really serious." (S4: 541-543)

Expressed vs. Actual Knowing

Many believed that they knew what it would feel like to experience a concussion because of their previous concussion education, however, the actual experience of a concussion was not as they expected, so they were unable to manage their injury as they expected they would. The experience of actually suffering through a concussion and the consequences on academics and sport participation (actual knowing) served to influence future reporting intention more than the knowledge of signs and symptoms learned from previous concussion education programs. This expressed knowing versus actual knowing was only evident once a concussion had been experienced:

> "I realize that there is so many things like my mom will be like, like I remember 3 weeks after my concussion I was driving my mom, I was picking her up from work, and she was like where are you going because I was heading in the complete opposite direction. She said this is not good and you need to take this serious. That is when I was like ok, but I felt like I didn't have a headache, I wasn't nauseous, but it is like some things aren't as noticeable that are affecting you, some things you are not going to notice physically. You are not having a headache, you are not feeling pain, but it is affecting you internally like it is." (Q6: 142-150)

> "From not having a concussion I didn't really think… I knew it was a severe injury to have but I didn't think it would have all these little complications with like studying and focusing, or driving or little things like that, even moving your head" (U7: 211-214)

Role of Personal Experience

Participants who reported increased concussion knowledge at post-season had not been given any formal education over the course of the season, therefore their improved knowledge came through experience rather than programmed teaching. Participants' actual knowledge of concussion, gained through personal experience, supplemented the expressed knowledge that the participant started the season with. While the actual knowledge of concussion improved for all participants who experienced concussion symptoms over the season, personal experience did not necessarily lead to improved intention to report future concussions. For some, increased awareness of symptoms and their effects on activities of daily living influenced their decision to report. This is illustrated in the following quotes:

> "…but again you get a different perspective on it once it happens" (U7: 244)

> "Like I said you don't really realize the severity, you don't really realize how it can affect your life until it happens. It is not a good feeling and not something that you want to repeat. I think that feeling, that not so good feeling, is greater than the not so good feeling that comes with not playing. I think it is easier to deal with no playing because of that injury than it is to continue on. I think that people who haven't gone through it don't really know unfortunately that is what it takes sometimes for people to realize but I think that is definitely the case." (T12: 431-437)

> "I don't think people are uneducated I think people understand the symptoms of a concussion I think it is more of the severity. I don't think people realize how severe they are and I think somebody just having a minor concussion is not going to impact them. I think it is almost like people the hard way, like I learned the hard way right." (Q6: 725-729)

While the role of personal experience increased the awareness of the effect of symptoms and the process of recovery after concussion, this did not necessarily impact

future intention to report. One athlete with a history of multiple concussions expressed a decreased intention to report based on her prior experience with concussions because of her assumption that she always recovered:

> "Interviewer: Do you feel you are more likely to play with symptoms now then you were back then or less likely to?
> Athlete: More likely to.
> Interviewer: What is the…
> Athlete: Probably because I don't want to be out like I was that long and it made me mad that I couldn't play hockey for that long. So if it is not going to be that bad then there is no point because I know I can go through it kind of thing."(R4: 167-174)

Another participant with a history of multiple concussions, long recovery times, and expressed and demonstrated knowledge of the potential consequences of mismanaged concussions still did not intend to report future concussions:

> "Something will kill me anyways, it is fine, whatever, let me enjoy it right now. I know how serious they are but I think of it as the here and now, in the moment, not in the future, like in 20 years where if I am lying in a bed like not able to think or remember anything, I just go with this moment right." (S4: 546-549)

One participant who had received formal concussion education in the past, as well as had prior personal experience with concussion indicated that she did not intend to report future concussions. Despite her appreciation of the seriousness of concussion and potential long-term consequences of mismanaged concussions, she believed that she would choose to hide future symptoms:

> "As an athlete I am one of those people who think that it is just part of the game. It happens and I am smart enough to know the consequences but I am not smart enough to do much about it I guess (laugh). I 'm in health science and I know the effects of it and I know how it affects you and stuff but there is still a whole part of it like being an athlete and the varsity athlete and you don't want to let people down. There is that part of it; I don't think it is just super black and white." (R12: 113-118)

Long Term Consequences

The long-term consequences of concussion were mentioned by all participants, with no uniformity between the participants. Participants who experienced concussion symptoms expressed varied opinions about their future intentions to report, with one participant stating:

> "So I would say that I am a bit more cautious about them but not necessarily that I will stop playing with them but it is like I know more now about it. It is a more serious injury than what I thought before" (R4: 528-530)

Other participants who reported symptoms to medical staff during the season expressed the intention to always report symptoms in the future as they now have increased understanding of the potential consequences if they chose not to report. Similar intention to report were expressed by those who experienced symptoms and did not report them. For example, two men's hockey players expressed their intentions to report future concussions, even though only one reported his symptoms this season. Both are older athletes and noted the difference in their intentions now that they are close to being finished their collegiate careers:

> "Athlete: At the end of the day my health is more important than collegiate hockey. There was a time in my life where maybe it wasn't but I guess it takes something like that to open your eyes a little bit.
> Interviewer: Do you think the fact that you are older now affects that decision making?
> Athlete: 100%. I found myself I would say even last year doing anything and everything to continue my hockey career but I think this year through a multitude of reasons made me think about the future, my future and certain circumstances that I am aware of that I don't want to be a part of and that is not how I want my life to be growing up and having kids and not being able to play with my kids or not being able to drive to see my family because I have concurrent issues with my head." (T12: 352-362)

> "It is just not worth it anymore, maybe if it was four years ago or 3 years ago when I was first coming in or my second year and I still was all in for hockey and not anything else but it has definitely changed. I don't know if it is more maturity or what but it has definitely changed." (T15: 1081-1084)

Despite awareness of the long term consequences of concussion, younger athletes tended to be comfortable with dealing with the effects later on, while the older ones were more concerned about their ability to work and function normally as they aged. One first-year athlete with a history of concussions reported:

> "I wouldn't want to sit out because it is realizing your hockey career is going to be over real soon so it is like suck it up for a bit, you have the rest of your life to deal with that stuff (laugh) that is what goes through my head anyways." (R12: 546-549)

The willingness to "deal with it later" was a consistent message delivered by most athletes, it was expressed in both the long and short term in relation to symptom reporting. Some were willing to delay reporting until after a game, at a break in the season, or even until the end of the season in order to continue to play. The notion that it was okay to wait because whatever event was immediate was more important than the future consequences was common between sexes, sports, and ages (except the 2 oldest athletes).

Influences to Non-Reporting

Choosing whether or not to report their concussion symptoms was a complex process that often needed to be made in a short period of time (e.g. between shift in a game, or when medical staff attended to them on the field). Often the default-mode for the participants was to hide or diminish their symptoms when asked about them following a hit or other mechanism that may have caused a concussion. In both the short and long-term, other people, one's internal messages, the desire to play, and the timing of the injury in the season, all play a role in the decision to not report.

Role of Others

Similar to the effect of previous experience having both positive and negative impacts on reporting intention, the role that others play in the lives of a student-athlete impacts their decision to report concussion symptoms. These "other" people may include medical staff, coaches, teammates, parents, professors/school administrators, and media. Every participant provided stories of how others had impacted their decision to report, with both positive and negative reporting behaviours resulting from those interactions with others.

No participants had witnessed or experienced coaches forcing athletes with concussion to return to play, however participants expressed the strong role that coaches play in their decision to not report their symptoms. One athlete reported:

> "I can't stop playing because I need to show them that I deserve this spot. Also because I am on scholarship, I was like he is paying me to play so I had better play so that he doesn't regret the decision. I think that was a big thing" (S4: 289-292)

The desire to prove herself to the coach led the athlete to hide her symptoms in order to continue playing. Interestingly, this same athlete reported that her coach would be the first person she would tell if she felt that she couldn't continue playing with her symptoms. She felt that her coach would look out for her health, while at the same time being the primary reason why she would continue to play when concussed:

> "I would be more likely to tell him because he won't tell anyone and he will look out for me. If it is serious then he will take me off and if it is not too serious then I know he will let me play" (S4:701-703)

Every participant mentioned that their teammates did not directly try persuade them to report or not, however, most expressed fear of losing their spot to a teammate or the notion that people would talk about concussed teammates behind their backs as influencing their decision not to report. One athlete who experienced a concussion over the season reported that:

> "It wasn't really ever explicitly said but it was kind of like at the same time if I was walking around and I am out and I am doing stuff you would

> think like they should be alright. So like I wouldn't say that anyone ever had that perception of it but I could tell by talking to some people about it when they asked. They kind of had that look on their face that maybe you could be back, do you know what I mean?" (U7: 440-444)

Most participants noted that the pressure placed on athletes by others is not deliberate, but yet contributed to the understanding that there is an expectation that they should continue to play when injured. This was consistent amongst participants regardless of sport or sex, for example:

> "I feel like it is more them that feels they need to be there for the team, I don't think it is the team pressuring. Obviously it feels like it but I think it is more the player thinking like I need to help the team. I guess the team is not meaning to do that but because it is a team environment and you just want to help the team it would have an influence on your decision" (Soccer Player:487-491)

> "I don't think it is a deliberate thing, I think it is being in that environment with your team and you don't want to miss out on that. I wouldn't say it is anyone in particular's fault for any of that pressure on you but I think it is definitely there" (Hockey Player: 513-516)

Interestingly, participants expressed support for teammates who chose to report their own symptoms, and relayed stories of support given to them when they were concussed, but still saw teammates as a barrier to reporting in the future.

The influence of others was also reflected in observing the experiences of others. Many participants discussed hearing about the long term effects of concussions on a former coach and the death of Rowan Stringer, a 17 year old high school rugby player who died after returning to play after suffering a concussion, and suffered a subsequent head injury (Rowan Stringer Ignored…," 2015), as factors in their decision making process. Observing the effect of concussions on others first-hand made the consequences real and informed the participants of the processes and factors that play into the return to play process. One hockey player, who saw both a former coach and teammate suffer from concussions, expressed how it affected his views on concussion:

> "Athlete: I guess it kind of opened my eyes to how severe concussion can be and like I said a teammate that went through it this year too. It has become a lot more I would say like aware in my mind and more serious to report a concussion because I mean that happened to our coach a long time ago and it has been dragged on for I don't know 20 or something years, however long and he is still suffering pretty bad from the stories that I have heard and from him.
> Interviewer: Do you think that would change the way you would manage yourself in the future?
> Athlete: Yes 100% just because of the long term effects. I mean you know the long term effects when it happens or I knew long term what could happen but it was in 1 ear and out the other kind of thing. Once you actually see it and hear it and you can actually physically see it on someone it is kind of scary" (T15: 397-408)

The messages received from others, both positive and negative, were internalized over the course of the athletes' career and often played against their knowledge that concussions are serious and should be reported.

Role of Self

While the experience and influence of others played a key role in non-reporting of symptoms, the role of "self" also emerged as an important factor in the decision to hide or minimize symptoms. The role of self is different from the influence of personal experience on reporting behaviour as it places the "self" in the context of the team or group, and affects reporting based on how one sees themselves within the group. Questionnaire data indicated that most participants would expect safe reporting behaviours from others, and would not think badly of a teammate who decided to report his or her concussion. In contrast, such behaviour was not expected for oneself, as expressed by participants in interviews. Participants saw themselves as different from their teammates – they held themselves to a higher standard, and felt that they were needed by the team in order to contribute to the success of the team. One participant described the need to be there for the team:

> "I am very competitive so I don't want to lose that spot and I don't want to take away from the team so I want to make sure I am back for that" (S19: 709-710)

They also felt that they were capable of playing through a concussion, whereas they would not have the same expectation of a teammate in the same position:

> "I am just a different person (laugh) and I push myself more than other people will push me. So I am harder on myself kind of deal. I would be like you are fine, just go out there and you want to play" (R4: 690-692)
>
> "Just because of who I am. I feel I can keep pushing through it. If it was actually something that I felt was really bothering me then I would say something about it but if I can get through it and I feel that it is fine then I will" (S19: 447-449)

The role of "self" placed the participants at a different expectation level for themselves when compared to their teammates or other athletes. They could always find a reason why they should not report their symptoms while simultaneously supporting a teammate or other athlete who had decided to report. This may have been influenced by the limited playing time available and the awareness that if they sat out, there was a chance that they could lose their spot in the lineup, whereas if another person reported their symptoms, it would open up a roster spot that they could potentially fill:

> "There are other people who can technically fill in for me and we have the same play and what if they play really good and I am pushed to the back" (R4: 802-804)
>
> "Well we have more than enough guys to suit up for a game and we usually sit guys in the stands so if you are hurt and unable to play obviously your name is not going to get called and that could drop you down the line-up so you kind of keep it a secret." (T15: 257-259)

The role of self in choosing to not report symptoms of a concussion was expressed in many different ways, however, the sense that they were tougher, more important, or in some way more capable of playing through their symptoms led the participants to have less safe expectations for their own behaviour than that of their teammates. When asked if all concussions should be reported, one participant responded:

> "If it is someone else yes but if it is me no (laugh). I don't know if it is because I have had so many that I can look out for myself" (S4: 622-623)

Desire to Play

Like the effect of the self and others on their decision making process, participants expressed a common desire to play as a major factor in their decision to not report. Many athletes reported that missing any opportunity to train or compete was not worth the positive effect of faster healing times and improved long-term prognosis.

> "Interviewer: What are the consequences of reporting your symptoms?
> Athlete: You don't get to play, it takes forever to get back in and it is not on your terms it is on someone else's terms so you have no control over that and for me it is just you are taken out of the game. Even practicing, even if I couldn't practice just watching just kills you. Just not being able to play, losing play time is a big thing." (S4: 638-642)

The desire to play was reflected in many ways – a university athletic career is short, the team needs them to play, the love of the sport, and an internal drive to compete. Often the participants relayed many different reasons why they need to play, and the internal drive to play overrides messages (both internal and external) that they should not play when symptomatic.

> "I would feel like I need to help the team 'cause I know that my coach or players wouldn't expect me to play especially anyone would tell me if they knew to go and report it. I feel like just for myself I would feel like I need to play more than anything" (S2: 785-788)

> "Interviewer: Does that desire to play affect your willingness to report?
> Athlete: Yes
> Interviewer: Do you think it still would?
> Athlete: Now after my concussions? I think a little bit. I think an athlete always has that drive, I want to be on that field, I don't care, I want to be on the ice, I don't care. So I think a little bit but I think I would report it more so now" (Q6: 630-636)

Timing in the Season

Combined with the desire to play, the time of the season when the concussion occurs plays a strong role in an athletes' choice to not report. All participants agreed that it would be very easy to report symptoms in the off season as it would have no consequence on their playing time. Most also noted that they would report symptoms going into or during exam time as they would not want to affect their grades. It should

be noted that final exams are completed at a time when there are no official training sessions or games, and that the participants did not place the same importance on reporting symptoms during midterm exams, when they would still be practicing and playing. When asked about certain times of the season when would be easier to report, all participants agreed that playoff or championship time would be the least-likely time that they would report, with most athletes stating that they would actively hide their symptoms until the season had finished. One athlete who had experienced her concussion coming into playoffs, and reported her symptoms to medical staff, expressed an expectation that she would report all future head injuries even in playoff time. However, the other eight participants (regardless of their safety levels reported in the questionnaires or interviews) all expressed a decreased willingness or the outright refusal to report during playoffs. Even an athlete who expressed very safe reporting intentions in her questionnaires and an expectation that she would report all future concussions had a different expectation for playoff time:

> "Interviewer: It sounds like you are very willing to report your symptoms, if you had a headache, if you had dizziness, would you have that same willingness to report in a playoff game as you would in a pre-season game?
> Athlete: Probably not.
> Interviewer: So even based on your own personal experience you still would say that your threshold changes for a playoff game?
> Athlete: Yes
> Interviewer: What would that new threshold be?
> Athlete: I don't know if I would have one.
> Interviewer: So you would just…?
> Athlete: Yes I think I would just go and say I will deal with this after, I am fine now, just let me go and I will talk about them after." (Q6: 654-668)

The following quote illustrates the common expectation from most participants, who at various parts of their interviews, were consistently able to find reasons or excuses to not report:

> "I think you can always find an excuse why you shouldn't report it. So like hey this is my last year and I am not going to report it. Oh this is my first year; I am fighting for ice time, like I think there is always a reason for you

> not to report it. It is the beginning of the season I don't want to miss the first half of the season; if it is the last then you don't want to miss the last half. There is always a reason you are not going to say anything about it. I guess that is the way I see it like there is always some sort of reason that gives you an excuse not to report it or not to take time off from playing" (R12: 743-750)

Reporting Threshold

When making the decision to report concussive symptoms, participants expressed specific levels at which they would choose to report their signs and symptoms. This is referred to as "reporting threshold" and is influenced by personal experience with concussion, the notion that concussion is an "invisible injury", the type, severity or duration of symptoms and the legitimization of the experiences of the concussed athlete by others. Many of the participants in the quantitative portion of the study reported that their threshold for reporting future concussions had dropped from pre- to post-season. However, when probed during interviews, most participants expressed little intention to report their signs and symptoms if they were not obvious to others, if they did not affect their athletic performance, and if they were not tested using objective tests like the Immediate Post-Concussion Assessment and Cognitive Test (ImPACT).

Invisible Injury

Participants reflected on the idea that concussion is an invisible injury that, unless it is extremely severe (vomiting, loss of consciousness), no one can see and it is up to the athlete to report his or her symptoms. While they all agreed that concussions are a serious injury, the fact that others cannot see how bad it is negatively affects intention to report. If coaches, teammates, and spectators could not see the injury, participants felt that they needed to continue to play for fear that others would not believe that they were injured, or would think less of them because they were not playing through the injury. The invisible nature of the injury also played into the theme of desire to play, and allowed for hiding of the injury from others. It was also noted that because most musculoskeletal injuries are obvious (bruising, walking with a limp, etc.), it was obvious

that those athletes were actually injured, whereas those with a concussion could be seen as faking or exaggerating their level of disability:

> "Interviewer: Do teammates treat those with an obvious musculoskeletal injury differently than they treat those with concussions?
> Athlete: I would like to say no but I know for a fact that in some minds the gears must be turning as to how serious this concussion really is. I mean obviously, like I said, the physical evidence of a cast you know somebody can't hold a stick or put on a skate. They can't play, it is impossible for them to play and I think that it is very possible for some guys to be thinking ok you have a concussion and we know that but how bad is it. They may compare themselves to that person whereas they say I have had a concussion before and I have played through it why can't you play through it or you know how serious is this, is this a minor one, like you said, it goes back to not being able to see the severity unless you are the actual affected person." (T12: 458-468)

One participant missed a lot of the season due to a concussion and found it challenging that teammates and coaches expected her to attend games and practices even though she was told by medical staff that she could not.

> "Interviewer: Do you think the coaches put more pressure on athletes with head injuries then with those visibly injured athletes to return?
> Athlete: Yes. I think also the athlete , I know myself, I felt pressured to come back because it is like I am walking, I am stable, I can go to practice but my coaches were saying you need to come to practice regardless of injury if you are able to get there, get there right? So the first practice I tried to go to and it is a 2 hour practice in the sun and I told my coach I can't. This is really bothering me and it almost felt like I was a burden, oh you can't come but you are fine, it is just your head, you can walk, talk, you are fine but it is hurting me. I am in physical pain, you can't see it but I can feel it." (Q6: 454-463)

For the participants, having a visible indicator of an injury (e.g. a cast or crutches) legitimized the fact that he or she wasn't playing:

> "Athlete: Even one time I was like sitting in the stands because I was injured I forget what it was last year, and you go up to the parents and they are like oh what is wrong and it is oh I have this injury. But then someone else is concussed next to me and it is people more or less look at you and say, ok someone has a boot on their foot and then this person

> is injured but they don't have anything wrong, like “on their person”. So it is like are you really injured kind of deal.
> Interviewer: Do you think parents feel this way as well?
> Athlete: I don’t think they think that, but it is even from them asking that.” (R4: 711-719)

> “Let's put it this way if you are in the stands with a concussion and you are cleared to go watch but not participate people look at you and think A. either you are injured, sick or you're a healthy scratch because you don't have an apparent brace or cast or crutches or any sort of significant sign that you are out because of an injury. [If] you're not able to play people obviously jump to the fact that you must be a healthy scratch because even if you were sick you wouldn't be there if you were too sick to not play and if you were sick it goes back to that hockey player status where we are all too tough to not play through things.” (T12: 442-449)

The invisible nature of the injury also made it hard for coaches to respond appropriately to a concussed athlete, and allowed participants to continue playing while symptomatic.

> “Interviewer: Do you think it is different for coaches when they can see somebody with a broken leg or a sprained ankle then somebody with a concussion?
> Athlete: Yes absolutely. They can see that physical pain, they can see ok it is broken, or something is broken. With a concussion you can't see, you can't...unless the symptoms are very severe, they are throwing up or they are knocked out or they can't see. Like something more severe but when it is something minor it is hard to see especially when the player is saying I am fine” (Q6: 446-452)

A number of participants also referred to another athlete who suffered a non-sport-related concussion over the season. This athlete had visible injuries to the head and body that were obvious to others, and served to legitimize the concussion and long recovery period. Invisible symptoms allow athletes to hide their concussion, while also creating a situation where others may judge or look down on someone who does report, creating a cycle which continues to reward an athlete who does not report his or her symptoms.

Severity and Length of Time of Symptoms

Every participant, regardless of previous reporting behaviour, had developed a personal threshold of severity and length of time that they would need to be experiencing

symptoms before he or she would choose to report. There were two common categories that emerged – symptoms need to be present for an extended period of time, and the presence of a headache alone would not lead to reporting to medical staff. Every participant noted that symptoms would need to be present for at least 24 hours, with most stating 48-72 hours as their minimum time in order for them to report.

> "I would definitely need to take a day or two to realize that this isn't going away on its own so maybe that means something bad" (R12: 619-621)
>
> "I would say that if I had them every day for a week I think I would definitely say something. I mean it could be something, it could be nothing right but if I say something to somebody if something could be done about it at least people would be aware" (T12: 340-343)
>
> "Interviewer: What is your deciding factor, your threshold for deciding to report a concussion?
> Athlete: I think it is how long I have symptoms for. Like I said I have had headaches before but it was because I was dehydrated or I was stressed or I didn't have enough sleep. I feel like I try and rule those things out first and see if by drinking more water, getting more sleep if I could help with the symptoms but if they are persistent and prolonged then I will probably say something.
> Interviewer: What is prolonged?
> Athlete: A couple of days.
> Interviewer: So 48 hours, 24 hours?
> Athlete: Probably like 72 hours." (S19: 417-428)

As was mentioned by participant S19 in the previous quote, the presence of headache is not enough to prompt reporting to medical staff. Headaches were noted by all participants as a symptom that could easily be ignored or rationalized as coming from a different cause (e.g. dehydration). In fact, reporting before the 48-72 hour time period had elapsed required severe symptoms or signs that others would notice.

> "I would have to be very nauseous, seeing stars, about to pass out kind of thing is, I think, to the point where I would actually say something and to the point where other people would be able to notice it I think. I would have to be, obviously if I got knocked unconscious that would be a pretty big thing too but a lot of the times I know that some people could look at

> me and they would say you're not OK and I was trying to brush it off. I still played through that but I think I would have to be to the point where someone else really noticed it as well for me to actually be able to say something." (R12: 384-391)

> "Interviewer: What is your threshold for bad enough? What is that level? Athlete: If I am actually not able to play. If I am knocked out or something otherwise I will get back up and keep playing. If I need to go to the hospital pretty much is what (laugh)." (R4: 143-145)

> "I think that one symptom is not a big deal unless it is one of the serious ones like knocked unconscious, dizziness, pressure in the head, depending on how much pressure. Something like little like not sleeping properly or having trouble concentrating unless it is really bad I don't think needs to be. As long as you make someone else aware of it that can watch out for you and you trust then it is fine." (S4: 623-628)

Having signs and symptoms so severe that others would notice and remove the athlete from play served to legitimize the injury and made it ok for the participant to stop playing. This helped to remove the "invisible" status from the injury, and took the onus off the athlete to respond honestly to subjective symptom severity questions.

Legitimization of Signs and Symptoms

The severe signs of concussion like vomiting, loss of consciousness and severe balance and memory impairment were commonly referred to by participants as the only reasons they would report their concussion. If their impairment was visible to others or was severely affecting their ability to play their sport, they would be more likely to report as it would legitimize their injury. To a lesser extent this was true for academic performance as well; for those participants where school was a high priority, symptoms that were negatively affecting their ability to do school work also resulted in earlier reporting intentions. The legitimization of a concussion also came through the use of objective testing, and participants used their results on the testing to show both themselves and others that they were truly injured and should not be playing.

> "I think the thing that impacted me the most was taking those concussion tests because like I said I wasn't feeling pain, I wasn't feeling physical pain." (Q6: 157-159)

> "Interviewer: So if I put you in a hypothetical situation back into November. You lied about your symptoms, felt fine, no problem, I am really good to go, randomly for some reason you had impact tested and on that test you said I have no symptoms, I feel good but you saw your scores had declined significantly from your baseline do you think that would encourage you to be more honest about your symptoms or would you fight it?
> Athlete: No I think that would kind of make you come to the realization that, well you personally knowing you have the symptoms and knowing you are not telling the truth about them and then a test that comes out and says those symptoms are confirmed by a computer test that would kind of make you come to the realization that you should do something about it instead of hiding it." (T15: 1051-1060)

The threshold of signs and symptoms required to report a concussion to staff varied among participants. During interviews it became clear that even participants who felt that they had learned from their experience and would be more likely to report in the future, would still find reasons or justifications for not reporting. For example, one participant who stated "I would definitely, definitely report it 100% if it happened again" (U7: 310-311) almost immediately then said:

> "It is a tough threshold because it is all like you think you are your own doctor so you just go off how severe you think it is right. I think time has a big thing to do with it. If it is a consistent thing that has been happening for a long time like if you had a headache for a long time or symptoms for a long period of time then I think I would definitely report it but again at the time of the incident I would kind of wait, not always a good thing, but it is subjective right." (U7: 325-330)

Waiting to see how the symptoms progressed did not match with his expressed intention to report 100% of all future concussions. Therefore, even within individuals, the process that one goes through to decide to report symptoms is made more difficult because symptoms are subjectively interpreted within the context of the time that they occur.

While there were common factors for personal thresholds for reporting signs and symptoms, the notion of choosing to report a teammate's concussion was met with varied responses among participants. There was no consistency in concussion history,

previous reporting behaviour, or future reporting intention as to whether a participant would choose to report on a teammate. Saturation was not reached for this idea, however feelings expressed by participants about whether they would report or not were always very strong and unwavering.

Sport Culture

Sport participation creates norms and values that are associated with physical and mental toughness, and accepts risks as an inherent part of sport. Research on sport has suggested that playing through pain and injuries is important for developing an athletic identity (Malcom, 2006). Coined "the culture of risk" by Nixon in 1993, the culture of sport normalizes pain and injury, and refers to the messages that athletes receive to play through pain and injury (Nixon, 1993). All athletes who were interviewed for this paper expressed both internal thoughts and external sources that affected their decision to report their concussive symptoms. Some had clear memories and stories that they could directly tie into their decision making process, and were able to draw concrete relationships between those internal messages and their thought process. What appeared more difficult for the athletes to address was the role of the culture of sport in their decision making process. Every participant reflected on stigmas and expectations that they felt as an athlete, but they often glossed over these as a second-thought when discussing reporting intention and behaviours. The role that sex, sport-type, and "playing hurt" plays in the experience of all injuries, not just concussion, contributed to the expectation that the participants would not disclose their concussions.

> "I think it is just the way that a competitive athlete is built. You don't want to....just because you know, like you know deep down you are supposed to, I think it is just that will to play, want to push through it. That is what we have been taught to do through a lot of things. I think it is just like that aspect of it. Yes I know better in my brain but is that actually what I want to do like I don't think that is....it is definitely an internal struggle I guess that you have a lot of the time. I think you don't want to pull yourself from the game. You think that you are less of a player if you pull yourself out of a game" (R12: 401-409)

The female athletes held the same expectation as their male counterparts, however, both sexes agreed that there is more social pressure on men to play through injuries. The hockey players felt that they were to be held to a higher standard in terms of toughness than athletes of the other sports, however, the athletes participating in soccer and lacrosse expressed a similar expectations on themselves as they would for a hockey player.

The normalization of pain and injury in sport was common for males and females, and was often learned at the beginning of their sport career. Complaining of injury or pain was commonly described as "showing weakness" and letting down teammates. The internalization of the messages of the culture of sport is reflected in the expectation that athletes will play through injuries:

> "I think athletes think oh I get hit in the head, it is normal to get a headache, obviously you will get a headache, you have just been hit by something or somebody had hit you. I think to them it is like walk it off, you will be fine because that is, playing contact sports, that is how I have been taught. Not necessarily with a headache, with any injury" (Q6:375-379)

> "Like I said I think it is just an athlete thing. I know across a lot of sports too I know it is the same thing. I know it is the same for soccer and lacrosse players, I know it is the same thing for them too. It is just that athlete mentality, you don't want to take yourself out of a game, do that to the team, or you are supposed to push through it" (R12: 506-510)

> "I don't think there is quite the same stigma in women hockey players as there is for males but that being said I think that there definitely are girls who don't report injuries because of the same mentality. They just want to play and they want to play for their teammates and they don't want to be seen as the injured person or a Band-Aid or whatever the names going around at that time" (T12: 798-803)

The internalization of messages that reinforce playing through injury and pain have been learned over a lifetime and come from parents, coaches, media, and teammates and work with the other factors to influence an athletes' decision to report concussive signs and symptoms.

Discussion

Many factors are involved in the decision to not report signs and symptoms of a concussion. One's knowledge of the symptoms and consequences of concussion are factored against the messages and drives to not report. Research focusing on effectiveness of concussion education and reasons why athletes don't report their symptoms is often quantitative, with a focus on drawing out measureable findings that can inform future educational endeavours. Much of the qualitative research to date has been informed by theoretical frameworks that describe reporting behaviour and inform education policies (Kroshus, Baugh, Daneshvar, & Viswanath, 2014; Kroshus, Garnett, Baugh, et al., 2015; Johna K Register-Mihalik, Laura A Linnan, et al., 2013b). The strength of the current study is its mixed-methods approach that explored the interplay between the quantitative survey data and in-depth understanding of the reporting behaviours of collegiate athletes.

All participants in this study expressed a high level of knowledge about concussion signs and symptoms and mechanisms of injury, however that did not necessarily reflect positively in their intention to report concussion. Recent research has focused on the creation and implementation of education programs to teach athletes about what a concussion is, as well as common signs and symptoms (Bramley et al., 2012; Echlin et al., 2010; Hunt & Henderson, 2009; Manasse-Cohick & Shapley, 2013). My findings indicate that such information is being received by athletes, evident in their high knowledge scores; however, the increased knowledge it is not reflected in reporting behaviour. In fact, over 40% of participants in my study did not report their concussions.

Sport has many physical, psychological and social benefits for those who participate, who often identify themselves as "an athlete". This title comes with a certain sense of self identity and attitude toward participation, which manifests itself in a strong desire to participate in practices and games. For collegiate athletes, additional considerations

such as scholarships, peer acceptance, and the support of coaches, may add to this identity and increase their internal drive to participate even when injured (Register-Mihalik et al. 2013). The desire and need to participate may override an athlete's understanding of the seriousness of concussion and cause them to lie about or hide their concussion symptoms.

Referred to in this study as "expressed versus actual knowing" the role of personal experience in the understanding of the effects and consequences of concussion cannot be understated. Even though over 91% of participants surveyed reported recognizing common signs and symptoms of concussion, interview data revealed that only upon experiencing a concussion did participants truly "understand" what it meant to have a concussion. For many it took others to comment on personality or mood changes, or the ability to look back on their deficiencies once they had recovered in order to see how affected they were by their concussion. Without the experience of their unique combination of symptoms, having to manage sport and academic requirements, or the protracted recovery period for some, the participants in the study did not truly recognize the seriousness of concussions. This "actual knowing" was represented in comments about not previously realizing that symptoms might change over time, that headaches weren't necessary for a concussion, and the complications and difficulties experienced in activities of daily living. The "expressed knowing" of being able to recognize signs and symptoms, and answering questions on a survey was not sufficient to inform the participants of the true experience of having a concussion.

Evident in the survey data was that a large percentage of varsity athletes experience symptoms that may be a result of a concussion and they are choosing not to report. In fact, with 17% experiencing ongoing symptoms, and over 20% reporting that their symptoms affected school performance, the effects of concussions on varsity athletes is an issue that affects more than just their immediate ability to play their sport. In post-season measures, over 60% of all participants were confident in their ability to recognize their symptoms of a concussion, and over 75% believed that they would be better off in

the long run if they reported. However, less than 50% were confident in their ability to report when they really wanted to keep playing. Studies frequently cite unwillingness to leave a game (desire to play), and fear of letting teammates down as reasons why athletes wouldn't report their symptoms (Chrisman et al., 2013; J Scott Delaney, Lamfookon, Bloom, Al-Kashmiri, & Correa, 2015; Kay, Welch, & Valovich McLeod, 2014). This was also evident in my study, with participants placing a high value on their desire to play. The drive to continue playing after injury or return to play before it is safe to do so is often lauded by teammates, coaches, and fans, and may contribute to the athletes' internal desire to continue playing even when they know it is not safe to do so. Further, for varsity athletes who dedicate hours of their day to training, mental preparation, and sport-preparation over and above their academic requirements, the loss of playing time diminishes their role as "athlete" and in a sense, places them alongside their non-athlete classmates, to whom they often cannot relate. The athletic identity, which refers to the degree that one identifies with the athlete role and looks for acknowledgement from others about that role (Brewer, Van Raalte, & Linder, 1993), may inform their desire or "need" to play, and play that above their own health and well-being. Athletes with a strong athletic identities have strong negative emotional responses, lower self-efficacy and self-confidence when unable to participate in their sports (Martin, Eklund, & Mushett, 1997). Athletes with a strong athletic identity accept risk, make sacrifices for the game, and do not show pain or weakness, which may contribute to unsafe reporting behaviours in those who see themselves in terms of their athlete identity above that of student. This was also evident with respect to reporting a teammates' concussion, where less than 20% of the symptomatic groups would report a teammates' concussion. Attitudes toward reporting another persons' concussion remained virtually unchanged from pre- to post-season for all groups in the study. When probed in the interview phase, participants commented on the importance of team and not reporting on a teammate. It was seen as unacceptable to report on a teammate, however, most participants stated that they would encourage their teammate to report his or her symptoms. Athletes in the current study identified as an athlete, and while academic

success was important to them, their primary focus was participation in their sport and membership with their team.

What was more concerning in my study was the lack of appreciation of the long-term consequences of concussions. Even though most interview participants were aware of stories of others who had died or had life-long complications as a result of one or many concussions, many of the athletes in this study were willing to "put off" dealing with their concussion. It was noted on many occasions that they would deal with the consequences in 20-30 years, which they equated to needing a knee replacement or not being able to walk as a result of their musculoskeletal injuries, even though many mentioned "you only get one brain". Many participants directly referenced a coach who had to retire as a result of his ongoing post-concussion syndrome, and acknowledged that his experience would make them think harder about reporting future concussions. However, even though they had direct personal experience as well as being able to witness someone struggle with the long term repercussions of concussions, they were willing to risk it in order to maintain their identity as an athlete, and their role on the team. This was also reflected in the survey data, in which at post-season, the symptoms reported group had decreased belief that they would be better off in the long run if they reported their concussion symptoms. On the other hand, the non-report group remained unchanged from pre- to post-season. Thus, despite their experience of suffering a concussion, and learning first-hand from the experiences of others, they had less appreciation for the future consequences than the non-report and asymptomatic groups.

In his study "The Lived Experience of an In-Season Concussion Amongst NCAA Division 1 Student Athletes", Matthew Moreau interviewed concussed athletes to examine their experiences and feelings after suffering a concussion during their season (Moreau et al. 2014). His findings suggest that athletes struggle with the perceived pressure from teammates and questions regarding the severity of the injury that coincides with the requirement that they are held out of games and practices. Because the athletes do not

have any obvious physical injury, their teammates, peers, and coaches cannot determine the extent of their injury. My study corroborates these findings with many participants expressing feelings of unspoken pressure from teammates and coaches to hide their symptoms or continue playing. The fact that concussions are invisible injuries plays a dual-role; it both allows athletes to hide their injury, while also de-legitimizing it to others. Phase one data showed that less than 5% of participants experienced visible signs like vomiting or loss of consciousness, while invisible symptoms like headaches, problems studying, and dizziness were experienced by over 20% of participants. Therefore, if the obvious symptoms are occurring far less often than the invisible ones, it not only makes it easier for athletes to hide their concussion, it also serves to de-legitimize the injury to others. To this end, my study found that when others who the athletes hold in a position of respect or power can "see" the effects, whether through visible signs or objective tests, it makes it easier for the athlete to report. Interestingly, one athlete reported that although she does not intend to report symptoms, if they were severe enough, she would eventually report them to her coach. This athlete believed that the coach would look out for her best interest, even though she acknowledged that there was unspoken pressure to play through injury. This contradiction illustrates the complex interplay in the relationship between athletes and their coaches; specifically, that a coach is paid to create a winning team and may not in fact have the athletes' long term interest at heart, yet athletes implicitly trust them. A number of female participants discussed telling a close teammate or having a teammate disclose to them under the assumption that that person would "look out" for them and ensure their safety. This trust in the coach or teammates who may not be educated in the recognition or management of concussions has the potential for both short-term and long term negative consequences. Conversely, by hiding concussion symptoms from medical staff, athletes potentially put themselves in danger because they believe that the medical staff will unilaterally pull them from play, instead of performing tests that will determine if it is safe for them to continue.

A new theme that emerged in my study was the “role of self”, which has not been previously explored in concussion research. By placing themselves as “different” or unique from their peers, the participants in this study demonstrated both in expectation and actions that they had different, less safe, expectations for their own behaviours following a concussion than for others. The viewing of oneself as unique may be similar to self-concept, which captures the overarching thoughts and feelings a person has about him or herself (Beadle, Ownsworth, Fleming, & Shum, 2015) and can be defined as a “collection of representations reflecting a person’s beliefs about his/her own functioning in various life dimensions” (Vickery, Gontkovsky, & Caroselli, 2005). It is a powerful regulator of behaviour and is learned over time, but is constantly changing and influenced by the outside world. Self-concept has been studied in relation to acquired brain injury and other serious musculoskeletal injuries (Beadle et al., 2015; Pargman & Lunt, 1989; Ponsford, Kelly, & Couchman, 2014; Vickery et al., 2005), however, the effect of self-concept on concussion, and more specifically concussion reporting, has not been previously reported. The notion that people develop an understanding of themselves as distinct physically, mentally, and emotionally has been studied in social science (Markus & Kitayama, 1991) and may be relevant to the decision making process involved in the intent to report in concussion. Specifically, even though athletes know the signs and symptoms of concussion, and understand the potential dangers of playing with one, they place themselves outside of the “normal” person and expect that they are different than others. This may lead them to believe that they will not experience the negative consequences, or that they will recover faster than others in the same situation might.

The decision making behavior influencing belief could also be explained from a physiologic rather than a behavioral perspective. Studies have found that the ventromedial prefrontal cortex (VMF) is involved in tasks that require self-reflection, and helps to determine the personal relevance of information (Moran, Macrae, Heatherton, Wyland, & Kelley, 2006). This same region of the brain is also responsible for decision making and control over powerful temptation (Bechara, 2004) and does not

fully develop until the age of 25. Often injured in concussions (Bigler, 2008), this area of the brain is not completely developed in collegiate-age athletes, and may play a role in the poor reporting intention and behaviour of these athletes. Interestingly, this study found that the oldest participants demonstrated the safest reporting intention of the nine who were interviewed. The two oldest participants noted that they were not sure if it was their age or the fact that their collegiate career was ending, but that they would report future concussion symptoms sooner. Both of these athletes had suffered concussion symptoms during the season, and had suffered a number of concussions in the past that they had not reported, but they both acknowledged that their intention had drastically changed from earlier in their university careers. If in fact brain maturity affects decision making behaviour, and self-reflection is linked to the same area of the brain, brain maturity and a changing self-concept may contribute to safer reporting behaviours.

Personal experiences, and the experiences of others, as well as internal messages (like the desire to play) help to inform athletes' decision making process when it comes to reporting injury. However, the individual does not exist in a bubble, so he or she is constantly hearing and internalizing messages from outside, which helps to develop their athletic identity. These messages may be positive or negative, implicit or explicit, and change depending on the situation. When groups of individuals who have internalized the same message interact, the message is enhanced. In the case of athletes, the sport culture is grown and developed within teams, institutions, and within the larger society. While often encouraging positive traits like hard work and teamwork, the sport culture is evident through all ages and levels of athletics and can result in negative consequences like athletes returning to play (or continuing to play) while injured or concussed (Nixon, 1993; Safai, 2003). Coined by sport sociologists, the "culture of risk" describes a state where being able to play through pain and injury are considered desirable attributes or traits for athletes, and are linked with toughness, strength, and commitment (McGannon et al. 2013). This culture encourages athletes to undertake risky behaviour and encourages and/or rewards pain and injury – athletes

understand this and in order to gain respect by teammates or achieve top performances, jeopardize their health and safety (Nixon 1992, Nixon 1993). This can create psychosocial issues for athletes such as emotional trauma, anger, social isolation, depression, pain and pressure to return to play after suffering an injury (Kontos et al. 2004, Mainwaring et al. 2010). This may be especially problematic when dealing with concussed athletes, as their injury cannot be seen by others and signs and symptoms vary so dramatically between people.

The participants in my study who chose to report their symptoms to staff reported a stronger belief that their teammates would think less of them if they reported than both their asymptomatic and non-report peers. Only 8% of the "symptoms reported" group believed that pre-season that their teammates would think less of them, but this number grew to 23% at post-season, while the scores for the asymptomatic and non-report groups stayed the same. It would appear that through their personal experience in dealing with their concussion, they were receiving messages from the group that would lead them to believe that their teammates viewed them differently than those who did not report. This was reinforced through interviews, during which participants expressed feeling pressure from coaches and teammates to hide injuries (specifically concussions), and the sense that concussions were not seen as as serious as other musculoskeletal injuries. When asked about explicit messages from coaches about concussions, every participant stated that coaches take concussions very seriously and would not force a concussed athlete to play. This is in contrast to their belief that they are expected to play after experiencing a concussion. This may be a result of expectations on behalf of athletes who have grown up in the sport culture, hearing messages of playing through injury, and expecting that their coaches would want them to continue to play, even though their current coaches truly do not want them to put themselves at risk. Therefore, the lifelong messages of playing through pain and injury override the safer messages coming through in the current sport environment.

In the current study, when asked about their personal beliefs about concussion reporting, the participants who chose not to report their symptoms had a stronger belief that if they report, they will hurt their team's performance, than their asymptomatic and reporting peers. Further, less than 50% of all participants were confident in their ability to report when they thought their teammates wanted them to play. Therefore, even though they are confident in their ability to recognize their symptoms, the influence of the team and the pressure to play through an injury, over-ride one's messages about symptoms of injury. The more they identify with the group, the more likely they are to conform to perceived group expectations (Kroshus, Garnett, Hawrilenko, et al., 2015), therefore, those who are highly invested in the sport culture, are less likely to engage in safe reporting behaviours, because they will no longer conform to the group.

The quantitative data obtained in this study demonstrated a high level of knowledge and education regarding concussion. However, when investigated more deeply through interviews, and the various factors and barriers involved in the decision to report symptoms were explored, it was apparent that knowledge regarding signs and symptoms and effects is not enough. Education policies that focus on knowledge of signs and symptoms and severity of concussion are being heard by athletes, but does not necessarily positively affect their reporting intention. Therefore, messages to athletes about concussion need to be presented differently than basic sign & symptom knowledge in order to see behavioural changes. If athletes see themselves as "different" from their peers, educational efforts need to address the personal motivators for different individuals in order to improve reporting intention and behaviours.

Areas for Future Exploration

A number of factors emerged during the interview process that did not reach saturation, and would benefit from future research.

For example, a number of participants reflected on concussions experienced during high school and the return to play process after those injuries. As a teenager still living with their parents, it would be expected that parents (along with physicians) would drive the return to play process, however, in those interviewed this was often not the case. The lack of parental involvement in return to play decisions is something that warrants further exploration, as early return to play (or not resting at all) may negatively affect those athletes as they embark on their collegiate career. While outside of the scope of the current study, it may be useful to explore changes in parent education as the current university-age athletes are the leading edge of the group that has increased awareness of the effects of mismanaged concussions. This group will also internalize the messages about concussion management and use them if they choose to have children – thus affecting future generations of athletes.

Another factor of interest but was not fully explored in the interview process was the idea of reporting on one's teammates. In both the survey data and interview phases there was a strong belief that an athlete should never report a teammate's concussion. However, in the case of one participant in the interview phase, she did report her teammate's concussion to staff, and felt that even though she would not report her own concussion symptoms, she felt it was her obligation to look out for her teammates, as she would expect them to look out for her. Most participants stated that they would speak to their concussed teammate and encourage reporting, but similar to their expectations of themselves, would only report a teammate's concussion if the signs were outwardly visible to others. This was similar to the findings of the quantitative phase, for which less than 20% of participants who experienced symptoms during the season would tell a therapist if they thought their teammate had a concussion. This would indicate that while these athletes would want and encourage their teammates to

report, it appears that the sport culture continues to influence their behaviour. Therefore, future education programs might be well served to address the negative connotations of “ratting out” one’s teammate.

As previously discussed, the process that athletes go through in order to decide whether or not to report their concussion symptoms is complex and involves internal and external factors. Decision-making is making is a cognitive process, or set of processes that an individual undergoes in order to determine a course of action (Fellows, 2004). An individual must be able to synthesize incoming, new information with previous experience and knowledge and integrate this with information about uncertainty, timing, a cost-benefit analysis, and risk and then the appropriate action is decided upon. The areas of the brain responsible for decision-making are not fully matured until the age of 25 (Bechara, 2004), therefore, the majority of varsity athletes are making decisions about symptom disclosure using a brain that does not necessarily have the capacity to fully appreciate the risks and benefits. Related to decision making is self-awareness, which involves the interaction between thoughts (objective knowledge of a situation) and feelings (the subjective interpretation or appreciation of the situation) (Sherer et al., 2005). Some athletes in this study referred to their lack of awareness of their physical and cognitive deficits after experiencing a concussion, which made it difficult for them to report. Others mentioned that their intention to report had changed (become safer) as they got older. The lack of self-awareness in an athlete with an immature brain that might lack the capacity to appreciate risks, may contribute to lower reporting rates in this cohort when combined with factors like desire to play and pressure from others. Assessment of decision making capacity was outside of the scope of this study, however, warrants future study to contribute to the body of knowledge.

This study was conducted at a mid-sized Canadian institution, drawing athletes from only three team sports. Future research on individual sports, a bigger variety of sports, and with a larger number of athletes would help to fill the gaps in the current study. Investigation of differences in attitudes between sexes was not possible in the interview

phase due to the small number of male participants, so an equal number of male and female participants would allow for conclusions on sex-differences to be drawn.

Finally, both the pre- and post-season surveys were retrospective, thus requiring clear recollection of concussion history and symptoms experienced in the season. While recall bias is a possible issue with retrospective studies (Coughlin, 1990), both the quantitative and qualitative phases of this study investigate knowledge and reporting intention as well as behaviour; so it is expected that the results accurately reflect participants' beliefs regarding concussion reporting.

Conclusion

Overall, understanding the complex interplay of reasons that athletes fail to report their concussions to staff can influence future education programs, improve recognition and assessment of potential concussions, and improve long-term outcomes for varsity athletes. By the time athletes reach university, they have received many messages about concussion signs and symptoms, and may have a clear understanding of what a concussion is. However, reporting behaviour does not reflect this understanding. In university-level athletes, the still-maturing brain and evolving concept of self, in addition to the pressures felt from the culture of sport, may override the education and reporting systems that teams and organizations work hard to develop and implement. Understanding the influence of personal experience and the experience of others in leading to safer reporting intentions (and subsequent behaviours), as well as developing an appreciation for the long-term consequences of concussions appears to be integral piece that is missing from current educational programs.

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Chapter 4 - Thesis Conclusions

Summary of Findings

This thesis sought to explore potential reasons why varsity athletes fail to report signs and symptoms of a concussion. Previous studies have indicated lack of education, desire to play, pressure from others, and membership in the sport culture all play a role in athletes' decision not to report. Further, attitude and intention to report seem to be indictors about future reporting behaviours. Through both quantitative and qualitative studies, researchers have attempted to determine which factors influence reporting behaviours, in the hope that interventions could be created that would improve reporting rates. However, few studies to date have allowed for both discovery and understanding of the factors involved in the decision to disclose symptoms. By utilizing a sequential mixed-methods approach, my study allowed for both exploration and explanation of the question of why varsity athletes fail to report concussion symptoms.

Results showed a high level of knowledge of the signs and symptoms, as well as awareness of the potential consequences of concussion in all participant groups (male/female, first year/upper year, and between sports). However, with over 40% of participants failing to report their concussion symptoms during the 2015 varsity season to medical staff, a gap between knowledge and behaviour was evident. Questionnaire data found that there was no difference in future reporting intention in those who experienced symptoms and those who did not, and participants from both groups had higher intention to report those signs and symptoms that would be obvious to others or would greatly affect their ability to play their sport (i.e. vomiting & dizziness). Participants with a history of concussion demonstrated a trend toward a less-safe attitude toward reporting future concussions than their healthy peers. This study highlights that education about signs and symptoms of concussion has been effective in increasing knowledge, but other factors are influencing poor reporting rates despite athletes' understanding of the seriousness of the injury.

When interviewed, participants confirmed the themes of desire to play, "invisible injury", internal and external pressures, and influence of the "sport culture" on their

decision to hide their symptoms that had previously been explored in the literature. New themes of the “role of self”, personal experience, lack of appreciation of the consequences, and “expressed versus actual knowing” emerged. In many cases, these factors over-ride the education that the athlete has received, and contribute to unsafe reporting behaviours.

The timing and type of symptoms experienced was also a key finding in this study. The participants dismissed the common symptoms of headache and fatigue and intended to report the visible symptoms or those that would affect their ability to play their sport. This, combined with the intention to report 48-72 hours after the injury occurs means that concussions are not being assessed and managed effectively in the crucial acute stages. Implications for recovery times, academic performance and long-term effects are worsened when management is delayed. Therefore, in a short varsity season and academic term, student-athletes have the potential to lose significant amounts of time away from school and sport.

My research also found that athletes have safe reporting expectations for their teammates; meaning that they do not expect others to play with a concussion, even though they would continue to play themselves. This is an important factor for athlete-education because if this message can be heard by the athletes, it may serve to dampen the risk messages in the culture of sport, and reinforce the idea that teammates want each other to be healthy and safe.

Future Directions

A number of factors emerged in the qualitative phase of my research that should be explored in future studies to determine if they are also contributing to the decision making process of varsity-level athletes to report concussions. The role of parents at earlier stages of the athlete experience may affect both the attitude toward concussions (and reporting) and the long-term health of the athlete, as parents are more closely involved in the return to play process following injury in younger athletes. The factor of

reporting on one's teammate also emerged in the interview phase but did not reach saturation. Further research into how to decrease the stigma of reporting on teammates may improve concussion reporting rates. Finally, it was beyond the scope of my study to measure decision-making capacity in my participants. However, immaturity in the regions of the brain that mediate decision-making and self-awareness in university-age athletes may play a significant role in their capacity to recognize and report their concussion symptoms. Future research into the role of decision-making specific to concussions would contribute to the understanding of reporting behaviours.

Limitations

My study was conducted on five teams representing three sports at a mid-sized Canadian university. Future research with a larger sample-size at a broader range of universities and with team and individual-sport athletes would strengthen the findings. An increase in sample size for both quantitative and qualitative phases would also provide an opportunity to explore differences between sexes and ages. Recall bias may affect responses on the pre- and post-season questionnaires because they were retrospective, however, attitudes and intentions would not have been affected by recall bias.

The individual questionnaires utilized in this study have been used extensively in other research, however, the validity and reliability of their use together has not been quantified. Future research to examine their reliability as a whole may be useful for scoring of the overall questionnaire as a whole.

Finally, ethical considerations in this study necessitated the non-reporting of certain demographic information that could have strengthened the findings. Future research at other institutions would remove that concern and allow for complete reporting of participant information and analysis.

Conclusion

In the absence of obvious signs and symptoms, and on-field objective testing, concussion assessment often relies on athletes to disclose their symptoms. If student-athletes are hiding their concussions from medical staff, they are putting themselves at risk for short and long term consequences. Educational initiatives have been effective at teaching recognition of mechanisms, signs and symptoms, and seriousness of the injury, but have not significantly improved reporting rates. This study highlights the need for education programs that address inter- and intra-personal factors that influence concussion reporting in order to improve attitudes and intention to report future concussions in varsity athletes.

Chapter 5 – Personal Reflection

Personal-Reflection

My first concussion occurred in my last year of university. At that point I had been a student trainer for 3 years, having worked with football, rugby, and hockey. Up until that moment I had learned about concussions in school and had worked with athletes who suffered concussions while playing their sport. I had been one of those people who believed that getting your "bell rung" was a normal part of sport, and I would often allow athletes to continue to play if they told me that they felt ok or they weren't suffering obvious signs or symptoms. Once I had the experience of trying to go to school and be a student trainer while being symptomatic for 2 months, I changed my views.

Fast forward 14 years. I was 6 months into my Masters study, working full-time as a Certified Athletic Therapist at a university, a mother of two, training for a half marathon and adventure racing, and working with national level athletes. By this point the seriousness of concussion was well-established, and I was vigilant with "my athletes" to ensure that they didn't return to play while experiencing the symptoms of a concussion. I educated athletes on the importance of full physical and cognitive rest, and worked with physicians to pull concussed athletes from classes until they had recovered. I thought I was a hardliner. I told athletes that I was looking out for their long-term well-being and that the brain doesn't heal the same way as other musculoskeletal injuries so I couldn't let them back to play until we were sure they were physically and cognitively better. I would advocate for the athletes with coaches, professors, and administrators to ensure the most effective recovery process. Then I suffered my fourth concussion.

I knew immediately that I was concussed. There was no way the blow I took to the head wouldn't cause a concussion. When I got home I rested, joked about my "latest concussion", and ImPACT tested myself and failed it miserably. I was back at work on Monday; driving to give a talk at another institution, teaching, treating injured athletes in the clinic, and getting my kids to and from daycare and their various activities – because I believed I had to, I thought no one else could do it. After a few days I was feeling "better" so I started some low-level exercise, and even though I didn't feel great

while doing it, I couldn't stop training because I had races coming up. When speaking to other people about my symptoms and what I was doing about them, people would ask "what would you tell your athletes to do?". I would tell them that they should be resting, not going to school, not working, and not exercising. And then those people would ask, "Why I wasn't doing that myself?", I would laugh them off because my situation was different.

It was 2 weeks after my injury occurred that I finally saw a doctor. I went to him with a plan in place about how I was gradually going to work myself back up to full training, and showed him how much better I was since the injury had happened. He took my plan and threw it in the garbage, told me that under no circumstances would I be exercising, and he told me that I was being ridiculous and that I should not have been working. That opened my eyes to the problems I was having. My next step was to meet with my Masters supervisor, who was teaching a course I was taking at the time. When I met with her, we had what I thought was a very rational, focused conversation about the issues I was having, and that I may need a little extra time to do the presentation for the class. After about 30 minutes, she stopped me and told me that if she didn't know me, she would have thought I was on drugs. I was manic. I could not keep a train of thought. My ideas and plans made no sense. And then she told me not to come to class for a month… It was at that point that I finally got it. It took two people in a position of power and responsibility to effectively stop me from continuing on the path I was taking. Ten weeks later I was finally symptom-free and able to resume all of my activities.

I am one of the lucky ones, the long-term effects of my multiple concussions are minimal, if any, and I have been able to come back to everything I did before my last concussion. It was my own experience with poorly self-managed concussions, and some experiences of my athletes that led me to my present study. Over the years, a few of the varsity athletes have made a huge impression on me as they went through the recovery process after concussion. One in particular commented to me that she thought she was better very early on after her injury, but it wasn't until she was truly better that she

realized how profound her deficits actually were. This led me to question whether my previous belief that the reason why athletes would tell me they felt fine and were ready to return to play was because they were lying or weren't educated. Maybe they didn't have the awareness of their actual deficits and truly believed that they were healthy. Other student-athletes have expressed the necessity of attending classes or going to work. The thought of missing course content or deferring exams and assignments filled them with such stress and anxiety that it exacerbated their concussion symptoms even more. As a student-athlete, the pressure of removing everything from their lives that is important to them (school, sport, social interactions) was such a terrifying idea that they would be willing to lie or minimize their symptoms so that they could continue with their normal lives. Once I started putting the pieces together, I started to question whether it was just the stubbornness of athletes and their desire to play that kept them from disclosing their concussion symptoms.

When I would tell people that my research was looking to answer the question of why varsity athletes fail to disclose their symptoms, they would look at me like I was crazy. We all know why – they want to play, they are young and think they are invincible, and concussions aren't that bad. But the more I spoke to athletes, reviewed the literature, and reflected on my own experiences, I knew that those weren't the only reasons. I am not an elite athlete, I am not young, and I know the seriousness of concussions, yet I still made some very bad decisions during the recovery process from my most severe concussion. So I knew it wasn't as simple as writing some variables on a questionnaire and asking athletes to reflect on their reason why they wouldn't disclose their concussion symptoms. I needed to know why.

My role as the Athletic Therapist for the pool of athletes I would use as participants was a challenge to overcome, both from an ethics perspective and for me personally. I know these athletes, some of them I see on an almost daily basis and we have developed relationships that might make it difficult for me to separate myself from them as the "researcher", or them to separate from me as "their" therapist. The ethics board saw

potential issues of trust and conflict of interest. I was not as concerned about the trust issue – I work hard to be professional and I think that the majority of the athletes trust me to do my job and that I would carry that over into my research. The bigger concern was conflict of interest – what would I do if an athlete told me in my researcher role that they were experiencing symptoms of a concussion? Research ethics state that I need to maintain the confidence of my research participants, but the legal and ethical concerns of my profession say that I need to ensure the health and safety of the athletes in my care. This led to many changes in methodology and research design in order to be able to effectively manage both of my roles in the process. I struggled to find a methodology that would encourage participant honesty, while not putting myself in a position where would need to compromise either of my roles. There was the option of only doing anonymous survey research, but I didn't feel that it would address my primary research question. In-season interviews or questionnaires would inevitably lead to dishonest reporting so that was not going to be an effective research strategy. Thus, the mixed-methods design was utilized to bring in the best of both worlds. I could obtain quantitative, anonymous data that would encourage honest reporting and inform my research question, and I could actually speak to the athletes after the season, when they were not at risk of me pulling them from play. I found the interview phase of my research so informative to my athletic therapy career even as the process was unfolding. I found myself "in the field" recalling statements made by some of the participants about how they would hide their symptoms, their motivations to minimize symptoms, and the difficulty of recognizing their own symptoms while in the heat of game play. This led me to change my line of questioning, or approach situations from a different perspective in the hope that I could obtain more honest responses.

One of the challenges of qualitative research is that the researcher is part of the research process. It is impossible for someone conducting an interview not to engage with the participant and bring in their own personal experiences, biases, and ideas into the process. The key is to recognize that this can occur and manage it as the process unfolds. Some of the participants in the interviews dealt with me directly after suffering

concussions so relayed stories and experiences that they knew I knew, so they might not explain in as much detail or clarity as I needed to answer my research question. . Learning how to draw out fuller responses without leading the conversation was an ongoing process through the interview phase. On the other hand, there were a number of instances when participants reflected on things I had said to them during their recovery from concussion that they learned from or helped them when they were suffering. This encouraged me as an athletic therapist that what I was doing was truly benefitting the athletes.

In coding the transcripts I found myself inferring meaning into their words because I knew some of the participants so well, and I knew their experiences. I knew when they lied or changed their answers from what really happened, and I brought in my own experience with them as we went through their recovery process together into my interpretation of what they said in their interviews. It was through working with the other researchers on the coding process that I realized that I was reading into some of the transcripts things that the participant had not actually said. On more than one occasion I found myself defending certain codes I had used because I was bringing pieces of other conversations with the athlete into my interpretation of the meaning of their responses as participants in the interviews. Once I realized I was doing that, it made it easier to really "hear" what the responses were to my interview questions.

As with everything in life, our personal experience with concussion is unique. It affects us all differently; in symptomology, effect on activities of daily living, and in long term consequences. However, there are some common factors and process that everyone goes through, both in the acute and recovery stages of concussion that need to be heard and understood in order to effectively recognize and manage this injury. One of the findings from my study that will influence my practice as an athletic therapist the most is the role of personal experience in the intention to report future concussions to medical staff. As with many life experiences, being able to teach people to learn from others' experience instead of having to go through the negative consequences of

concussion after not reporting would be safer in the long and short term for all athletes. Since the participants in my study seemed to only “get it” once they had experienced a concussion for themselves, I feel it is my job as a therapist to figure out better methods of educating the athletes in my care to make them “understand” the effects of concussion without having to experience them themselves.

Two of the participants involved in the qualitative portion of my study suffered concussions after they had completed their interview, and I found myself drawing on their responses in the interview when I was helping them manage their injury. In this case, my role as researcher helped to directly inform my practice as therapist as I had better insight into their own beliefs and feelings toward concussion. While it is not feasible for me to “interview” all athletes in my care prior to the start of their varsity career, I believe that it is important for me to draw on the findings from my research and truly engage with my athletes as they discuss their experience as they suffer from or recover from concussion.

Finally, my experience with my most recent concussion and the sense that I “had” to continue with my normal activities (work, teaching, child-care) is no different than the experience of the student-athletes who feel that they must continue to attend school, social events, and engage with the team. I was guilty of seeing myself as “different” than others in the same situation, and even though I knew cognitively what I was supposed to do and would have those expectations of others, I could not hold myself to that same set of expectations. If I, with a mature brain, high levels of education about concussions, and not having the same influence of the culture of sport as the varsity athletes, still engaged in unsafe behaviour, how could I expect them to make safe choices for themselves? The “role of self” in concussion reporting and management, to me, seems to be key in finding ways to increase reporting rates and improving recovery outcomes. We need to find a way to help people suffering from concussions, who are already cognitively impaired as a result of their injury, to see that just like their peers they will be better off in both the short and long-term if they report. This is a complex issue that

goes beyond the scope of this research, but I hope that my improved understanding of the internal and external messages that athletes are receiving, the effect of the sport culture, and the role of their own experiences will allow me to look beyond the basic signs and symptoms education. This, coupled with dealing with my own concussion places me in a position to truly advocate for the needs of the student-athletes as they navigate the complex world of academics and athletics.

Chapter 6 - Appendices

Appendix A - Certificate of Approval from the University of Ontario Institute of Technology Research Ethics Board

Date: *August 18, 2015*
To: *Jessica Salt*
From: *Shirley Van Nuland, REB Chair*
Title: *(14-132) Concussion Reporting Intention and Behaviour in Varsity Athletes*
Decision: *APPROVED*
Current Expiry: *August 01, 2016*

Notwithstanding this approval, you are required to obtain/submit, to UOIT's Research Ethics Board, any relevant approvals/permissions required, prior to commencement of this project.

The University of Ontario, Institute of Technology Research Ethics Board (REB) has reviewed and approved the research proposal cited above. This application has been reviewed to ensure compliance with the Tri-Council Policy Statement: Ethical Conduct for Research Involving Humans (TCPS2 (2014)) and the UOIT Research Ethics Policy and Procedures.

You are required to adhere to the protocol as last reviewed and approved by the REB. Always quote your REB file number on all future correspondence.

Continuing Review Requirements:

- **Renewal Request Form**: All approved projects are subject to an annual renewal process. Projects must be renewed or closed by the expiry date indicated above ("Current Expiry"). Projects not renewed within 30 days of the expiry date will be automatically suspended by the REB; projects not renewed within 60 days of the expiry date will be automatically closed by the REB. Once your file has been formally closed, a new submission will be required to open a new file.
- **Change Request Form**: Any changes or modifications (e.g. adding a Co-PI or a change in methodology) must be approved by the REB through the completion of a change request form before implemented.
- **Adverse or Unexpected Events Form**: Events must be reported to the REB within 72 hours after the event occurred with an indication of how these events affect (in the view of the Principal Investigator) the safety of the participants and the continuation of the protocol (i.e. un-anticipated or un-mitigated physical, social or psychological harm to a participant).
- **Research Project Completion Form**: This form must be completed when the research study is concluded.

Forms can be found at: http://research.uoit.ca/faculty/policies-procedures-forms.php

REB Chair Dr. Shirley Van Nuland shirley.vannuland@uoit.ca	Ethics and Compliance Officer compliance@uoit.ca

NOTE: If you are a student researcher, your supervisor has been copied on this message.

Appendix B – Letter of Support – UOIT Department of Athletics

UNIVERSITY OF ONTARIO
INSTITUTE OF TECHNOLOGY

Scott Barker
Manager, Intercollegiate Athletics
Department of Athletics and Recreation
University of Ontario Institute of Technology
2000 Simcoe St North
Oshawa ON L1H 7K4

June 2, 2015

To whom it may concern,

Please accept this letter as my approval for Jessica Salt to work with the UOIT varsity athletes (soccer, lacrosse and hockey) on her research into concussion reporting behaviour in varsity athletes.

I have met with Jessica to discuss the purpose of the research and methods she will be using with the varsity athletes, and I give her permission to use the Varsity 101 session to explain her research and recruit potential participants. I understand that the athletes' participation is voluntary, and their role or participation on their varsity team will not be affected or influenced by their participation in the study. I am comfortable that Jessica will be able to manage her professional role as Varsity Athletic Therapist with her role as researcher when interacting with the varsity athletes.

I can be reached at Scott.Barker@uoit.ca or 905-721-8668 ext. 2548 if there are any questions or concerns.

Regards,

Appendix C – Permission for Use of Content

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SAGE Publishing

Title: Rehabilitation of Concussion and Post-concussion Syndrome:

Author: John J. Leddy, Harkeet Sandhu, Vikram Sodhi, John G. Baker, Barry Willer

Publication: Sports Health

Publisher: SAGE Publications

Date: 03/01/2012

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BACK CLOSE WINDOW

Appendix D – Phase 1 Informed Consent

Informed Consent for Participants: Phase 1

Title: *Concussion Reporting Intention and Behaviour in Varsity Athletes*
This study (REB # 14-132) has been reviewed by the University of Ontario Research Ethics Board and has been approved as of August 18, 2015.
You are invited to participate in a research study involving athletes on the UOIT soccer, lacrosse and hockey teams. It is up to you to decide whether to be in the study or not and your participation is completely voluntary. Before you decide, you need to understand what the study is for, what risks you might experience and what benefits you might receive. This consent form explains the study. Please read this form carefully, and feel free to ask any questions you might have.

Prior to the start of the study, you will be given an opportunity to review the details of this study and ask any questions that you may have. *If you have any questions about your rights as a participant in this study, please contact the Compliance Officer at 905 721 8668 ext. 3693 or compliance.uoit.ca*

Principal Investigator:

Jessica Salt, Graduate Student, Faculty of Health Sciences
Head Athletic Therapist – Department of Student Life
University of Ontario Institute of Technology
2000 Simcoe St. North, Oshawa, ON L1H 7K4
Phone: (905) 721-8668 ext. 2156, Email: Jessica.Salt@uoit.ca

Faculty Supervisor:
Dr. Bernadette Murphy, Professor, Faculty of Health Sciences
University of Ontario Institute of Technology
2000 Simcoe St. North, Oshawa, ON L1H 7K4
Phone: (905) 721-8668 ext. 2778, Email: Bernadette.murphy@uoit.ca

Research Assistants:
Jessica Cohan
Steven Genis
Michael Penny
Brett Turpin
Kelsey Withers

Undergraduate Students, Faculty of Health Sciences
University of Ontario Institute of Technology
2000 Simcoe St. North, Oshawa, ON L1H 7K4

1) Introduction/Background

The long-term consequences of mismanaged or unrecognized concussions experienced during sport participation are a growing concern in the medical field. Physicians and therapists who work closely with collegiate-age athletes not only have to consider when it is safe to return these athletes to their sport, but also to class and work. One challenge is that current "best" practices such as computerized testing may not be capturing all the effects to the concussion, and athletes often need to report the signs or symptoms of a concussion in order to have it managed properly. This research study is being conducted to examine athletes' intention to report concussive symptoms and their actual behaviour if the signs or symptoms of a concussion are experienced. This study will use questionnaires, and post-season interviews to determine if changes in intention occur over the course of the season, and if attitudes toward concussion and reporting affect actual behaviour.

Currently, all UOIT varsity athletes undergo neurocognitive baseline testing using the Immediate Post-Concussion Assessment and Cognitive Testing (ImPACT) computer software, which provides a raw score in a number of different domains (reaction time, visual memory, verbal memory). If you suffer a suspected concussion over the course of the varsity season, you are re-tested on the ImPACT test and the 2 sets of scores are compared to see if there has been any decline. Because subsequent ImPACT testing is only performed after an athlete has sustained a suspected concussion, which often relies on an athlete reporting his or her symptoms, we do not know if we are missing detecting some concussions over the course of the season.

2) Purpose

The purpose of this study is to investigate how attitudes toward concussion explain differences in concussion reporting over the course of a varsity season in university-level athletes who have experienced concussion(s) versus those who have not. There are times when an athlete may not reveal to coaches or medical staff that he or she is experiencing the symptoms of a concussion, and we would like to know why. You will be asked to fill out two questionnaires at the start of the season, and another questionnaire at the end of your fall season. We will use the responses on the questionnaires to examine your opinions about concussions, their severity, and intention to report. We would also like to determine whether you have experienced symptoms from a possible concussion during the season.

Once the data from the questionnaires is reviewed, the primary investigator will interview selected athletes to discuss attitudes toward concussion reporting, and reporting behaviours in open-ended, semi-structured interviews. If you are selected to participate in Phase 2 of this study, you will be provided another consent for to review and sign which will outline the second part of the study more fully.

This is the first step in an overall study which will investigate how decision-making is affected in athletes over the course of the season, specifically in relation to concussion and head injury. However, the current study is looking to investigate athlete attitudes toward concussion in general, and more specifically, your intentions and real-life actions if you experience a concussion or head injury.

Your responses to the questionnaires will be coded so that the principal investigator (Jessica Salt) doesn't know who participated in Phase 1 of the study. All responses on the questionnaires are anonymous.

Your participation in this study is voluntary and you may choose to end your participation in the study at any time, with no repercussions. Please note that if you do sustain a diagnosed concussion, all of the normal UOIT Head Injury Policies and procedures will still be in effect and participation in this study will not change these in any way.

3) Eligibility

You are invited to participate in our research study and we would appreciate any assistance you can offer. Your participation in this study is entirely voluntary and you are free to decline taking part in this study. You may also withdraw from the study at any time without giving a reason and this will in no way have any negative affect on you.

We are seeking 50-75 male and female UOIT soccer, lacrosse, and hockey athletes between the ages of 17 and 25 for the initial stages of the study and 8-10 for the interview process (to be taken from the initial group of 50-75 once the season is complete and we de-code the data).

If you decide to withdraw from this study, your status as a varsity athlete or patient in the UOIT Varsity Athletic Therapy Clinic will not be affected.

4) Description of the study procedures

Session 1:

During the usual Varsity 101 session at the start of the UOIT varsity season, you will be asked to fill out 2 additional questionnaires. These include an information questionnaire, which includes information regarding sports history, demographic information, and some past and current medical information. You will then be asked to fill out a second questionnaire which will ask how you feel about concussions and head injuries.

- Total additional session time for the research (over and above the required Varsity 101) approximately 20 minutes

Session 2:

After the final game of the varsity soccer (November 15, 2015) or lacrosse season (October 25, 2015, or the last game of the first half of the varsity hockey season (December 4, 2015), you will be asked to complete another questionnaire which will ask about your season and how you feel about concussions and head injuries. The research assistant will contact you to set up a time that works best for you to complete the questionnaire.

- Total session time approximately 20 minutes

Once both sets of questionnaires have been completed, they will be released to the principal investigator (Jessica Salt) for examination and review. She will then select some individuals to contact for a potential interview. She will give the identifying code to the research assistant, who

will match the code to the individual (using the information you provided at the first session), and those individuals will be invited to participate in an interview session.
Jessica will not be given the identity of any participant until he or she has agreed to participate in the interview process. Once an individual has agreed to participate in an interview, he or she will be provided a second consent form to review and sign.

Every consideration will be taken to book all sessions around your availability – taking into account your class and work schedule.

5) Potential Benefits

Your participation will contribute to concussion management research which may help reduce the incidence and prevalence of future concussions, improve how they are managed and improve the overall recovery of a concussed athlete. More specifically, your responses will provide information on reporting intentions, behaviours and likelihood of athletes not reporting concussion symptoms, which can contribute to future educational efforts to more effectively teach athletes about the potential negative repercussions of not reporting concussion symptoms and playing while symptomatic.

6) Potential Risks or Discomforts

There is no physical risk associated with your participation in this study, however, there is a chance that you might experience some psychological stress while completing the questionnaires.

The principle investigator, Jessica Salt, is the Varsity Athletic Therapist for UOIT teams so you may feel that you need to participate in this research in order to play on your team. Participation in this study is completely voluntary and lack of participation will in no way affect your status on the team or the quality of care that you would receive by the therapy staff if you are injured during the varsity season. If you are injured during the season, Jessica's role as Varsity Athletic Therapist will take precedence over the research role, and all injuries (including concussions) will be managed as per UOIT medical policy and procedure.

Jessica will not know who has chosen to participate in the research study, and will not see questionnaire responses until the end of the fall varsity season, therefore, your participation and responses will in no way affect the type of quality of medical care that you receive. Please note, there are two other Certified Athletic Therapists and various Student Therapists who are available to assess and treat injuries in the Varsity Therapy Clinic, so if you require treatment for an injury and you are not comfortable dealing with Jessica, you are free to utilize the services of a different therapist.

UOIT has counselling services available to all students and may be contacted if you experience any stress or concerns after you have completed your questionnaires. Registered mental health professionals are available using the following contact information:

Student Mental Health Services: 905.721.3392 or studentlifeline@uoit.ca

Location:
UOIT Student Life

- **North Oshawa location:** U5 Building
- **Downtown Oshawa location:** 61 Charles Street Building, Room 225 (by appointment only)

Hours:
Monday to Friday, 8:30 a.m. to 4:30 p.m.

7) Storage of Data

Questionnaire data will be stored in the research supervisor's office until the end of the fall varsity season and will not be accessible to the principal investigator (Jessica Salt) until the end of the fall season. The research assistant assigned to your team will code all of the names of the participants in an Excel spreadsheet and remove all personal identifiers from your questionnaire. This excel document will be on a password protected hard drive accessible only to the research assistant, which will be stored in the supervisor's office, and is not accessible by Jessica Salt. All identifiers will be destroyed by the research assistant upon commencement of Phase 2 of the study.

Once the questionnaire data has been released to Jessica Salt, it will be stored securely in her office in the Campus Health Centre with no personal identifiers. The anonymous questionnaire data will be stored for 7 years, in accordance with the scope of practice of a Certified Athletic Therapist.

8) Confidentiality

All data collected will be confidential and stored via a coded system, making the data anonymous for the duration of Phase 1 of the study. The codes will be kept by an external party (research supervisor), not involved in the research process. Upon completion of the fall varsity season, the primary investigator (Jessica Salt) will receive the coded questionnaires for examination. The participants will remain anonymous to everyone except the research assistant assigned to your team. Once participants for Phase 2 of the study have been selected, all codes, identifiers and participant information for participants in Phase 1 only will be destroyed.

All participants will be referred to by code in correspondence, written papers and presentations.

In no way will your responses on the initial set of questionnaires affect your medical treatment during the fall varsity season.

9) Right to Withdraw

You are free to withdraw from the study at any time without prejudice. There will be no personal consequences associated with the withdrawal. If you wish to withdraw from this study, simply tell the research assistant that you no longer wish to participate. If you do choose to withdraw, your data will not be used for study purposes.

If you decide to withdraw from the study, your status as a varsity athlete or type or quality medical care in the Varsity Therapy Clinic will not be affected.

10) Debriefing and Dissemination of Results

The data from this research may be submitted to scientific conferences and peer reviewed journals. All published data will be coded so that your data is not identifiable. At your request, and at the completion of this study, you will be sent a summary of the research findings. You are also free to meet with Jessica Salt upon completion of the study to learn about the findings and conclusions reached by the study.

11) Thank You

Jessica Salt and the research assistants would like to thank you in advance for your participation in this study. Your time and contribution is much appreciated and your responses will contribute valuable information toward this research. We understand that your time is valuable and you have taken time to participate in this study so we thank you for this as well.

12) Questions

Thank you very much for your time and for making this study possible. If you have any questions or wish to know more please contact:

Jessica Salt CAT(C) BSc Kin Dip SIM
Certified Athletic Therapist, UOIT Varsity Athletic Therapist & Graduate Student
University of Ontario Institute of Technology
Faculty of Health Sciences
2000 Simcoe St. North
Oshawa, Ontario L1H 7K4
Phone: (905) 721-8668 ext. 2156
Email: Jessica.Salt@uoit.ca

You can also contact the faculty supervisor on this project, if you have any further questions.

Dr. Bernadette Murphy, Professor, Faculty of Health Sciences,
University of Ontario Institute of Technology
2000 Simcoe St. North, Oshawa, ON L1H 7K4
Phone: (905) 449-7053, Email: Bernadette.murphy@uoit.ca

For any other queries regarding this study, please contact the UOIT Research and Ethics Committee Compliance officer (compliance@uoit.ca and 905-721-8668 ext. 3693).

Signature Page

Please read the following before signing the consent form and remember to keep a copy for your own records.

To be filled out and signed by the participant. Please check as appropriate.

I have read the consent.	Yes { } No { }
I have had the opportunity to ask questions/to discuss this study.	Yes { } No { }
I have received satisfactory answers to all of my questions.	Yes { } No { }
I have received enough information about the study.	Yes { } No { }
I understand that I am free to withdraw from the study	Yes { } No { }

- at any time
- without having to give a reason
- without prejudice

I understand that I may be contacted by the research assistant to participate in Phase 2 of this study.	Yes { } No { }

Please Note: You will be provided a second consent form if you decide to participate in Phase 2 of the study.

I understand that my participation in Phase 1 of this study does not require me to participate in Phase 2 if I am invited for an interview session.	Yes { } No { }
I understand that it is my choice to be in the study.	Yes { } No { }
I agree to take part in this study.	Yes { } No { }

_____ _____

Signature of participant Date

_____ _____

Signature of witness Date

To be signed by the investigator:

I have explained this study to the best of my ability. I invited questions and gave answers. I believe that the participant fully understands what is involved in being in the study, any potential risks of the study and that he or she has freely chosen to be in the study.

_____ _____

Signature of investigator Date

Signing this form gives us your consent to be in this study. It tells us that you understand the information about the research study. When you sign this form, you do not give up your legal rights. Researchers or agencies involved in this research study still have their legal and professional responsibilities.

Appendix E – Phase 2 Informed Consent

Informed Consent for Participants: Phase 2

Title: *Concussion Reporting Intention and Behaviour in Varsity Athletes*
This study (REB # _14-132_) has been reviewed by the University of Ontario Research Ethics Board and has been approved as of (Date_August 18, 2015_).
You are invited to participate in Phase 2 of the research study involving athletes on the UOIT soccer, lacrosse and hockey teams that you began in August 2015. It is up to you to decide whether to be in this portion of the study or not and your participation is completely voluntary. Before you decide, you need to understand what the study is for, what risks you might experience and what benefits you might receive. This consent form explains the study. Please read this form carefully, and feel free to ask any questions you might have.

Prior to the start of the study, you will be given an opportunity to review the details of this study and ask any questions that you may have. *If you have any questions about your rights as a participant in this study, please contact the Compliance Officer at 905 721 8668 ext. 3693 or compliance.uoit.ca*

Principal Investigator:

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1) Introduction/Background

The long-term consequences of mismanaged or unrecognized concussions experienced during sport participation are a growing concern in the medical field. Physicians and therapists who work closely with collegiate-age athletes not only have to consider when it is safe to return these athletes to their sport, but also to class and work. One challenge is that current "best" practices such as computerized testing may not be capturing all the effects to the concussion, and athletes often need to report the signs or symptoms of a concussion in order to have it managed properly. This research study is being conducted to examine athletes' intention to report concussive symptoms and their actual behaviour if the signs or symptoms of a concussion are experienced. This portion of the study will use interviews to determine if changes in intention to report concussive symptoms occur over the course of the season, and if attitudes toward concussion and reporting affect actual behaviour.

Currently, all UOIT varsity athletes undergo neurocognitive baseline testing using the Immediate Post-Concussion Assessment and Cognitive Testing (ImPACT) computer software, which provides a raw score in a number of different domains (reaction time, visual memory, verbal memory). If you suffer a suspected concussion over the course of the varsity season, you are re-tested on the ImPACT test and the 2 sets of scores are compared to see if there has been any decline. Because subsequent ImPACT testing is only performed after an athlete has sustained a suspected concussion, which often relies on an athlete reporting his or her symptoms, we do not know if we are missing detecting some concussions over the course of the season.

2) Purpose

The purpose of Phase 2 of the study is to investigate how attitudes toward concussion explain differences in concussion reporting over the course of a varsity season in university-level athletes who have experienced concussion(s) versus those who have not. There are times when an athlete may not reveal to coaches or medical staff that he or she is experiencing the symptoms of a concussion, and we would like to know why. You were selected to participate in this phase of the study based of your responses on the questionnaires in Phase 1. The purpose of this phase of the research is to examine your opinions about concussions, their severity, and intention to report. Through the use of a conversational style of interview, it is hoped that you will use the opportunity to discuss your personal experiences with concussion, concussive symptoms, and your feelings regarding reporting of head injury signs and symptoms by yourself, and other athletes.

When the data from the questionnaires was reviewed, the primary investigator selected some individuals whose responses warranted further examination for this portion of the study. The purpose of these interviews is to obtain information from the athletes as to why they made certain choices/decisions over the course of the season, and compare those responses to current literature. The intention is to interview some athletes who suffered a diagnosed concussion over the course of the season (if any), as well as others who did not, so that we can determine any differences in attitudes and experiences between the two groups.

This is the second step in an overall study which will investigate how decision-making is affected in athletes over the course of the season, specifically in relation to concussion and head injury. However, the current study is looking to investigate athlete attitudes toward concussion in general, and more specifically, your intentions and real-life actions if you experience a concussion or head injury.

Your responses to the questionnaires in Phase 1 were coded so that the primary investigator (Jessica Salt) didn't know your responses until the fall season ended, and your identity was revealed to her when you agreed to participate in this phase of the study. Now that you have agreed to participate in Phase 2 of the study, she will be given the demographic information that you filled out in the first session (at the start of your varsity season), which will identify your name, email address and other sport information.

Your participation in this study is voluntary and you may choose to end your participation in the study at any time, with no repercussions.

Eligibility

You are invited to participate in our research study and we would appreciate any assistance you can offer. Your participation in this study is entirely voluntary and you are free to decline taking part in this study. You may also withdraw from the study at any time without giving a reason and this will in no way have any negative affect on you.

We are seeking a total of 8-10 male and female UOIT soccer, lacrosse, and hockey athletes between the ages of 17 and 25 for this stage of the study. These participants have be invited to participate in Phase 2 of the study based on responses to the questionnaires from Phase 1.

3) Description of the study procedures

Upon completion of the second session of Phase 1 of the study, the primary investigator (Jessica Salt) was provided all (coded) questionnaires for study and review. Participants with responses that warranted further examination were invited by a research assistant to participate in an interview with Jessica. Once you agreed to participate in an interview, you were provided this consent form and your personal information was released to Jessica.

Jessica will contact you to book a meeting time that suits your schedule. At that session, you will be asked to sign the consent form and allowed to ask any questions you may have. Once the consent form has been signed, the interview will begin. The interview is a conversational-type of session, allowing you to discuss your experiences freely and questions to arise out of the discussion. The interview will be audio-recorded to allow for review once the session has ended.

- Total session time approximately 1 hour

The responses to the interviews will be reviewed and compared to other responses, and will inform the final conclusions of the study.

4) Potential Benefits

Your participation will contribute to concussion management research which may help reduce the incidence and prevalence of future concussions, improve how they are managed and improve the overall recovery of a concussed athlete. More specifically, the interview process will provide information on reasons why athletes do not report concussion symptoms, which can contribute to future educational efforts to more effectively teach athletes about the potential negative repercussions of not reporting concussion symptoms and playing while symptomatic.

5) Potential Risks or Discomforts

There is no physical risk associated with your participation in this study, however, there is a small chance that you might experience some psychological stress while participating in the interview session. If you are selected for the interview section of the study, you will have an opportunity to decline answering any or all of the questions if you are not comfortable answering them.

The principle investigator, Jessica Salt, is the Varsity Athletic Therapist for UOIT teams so you may feel that you need to participate in this research in order to play on your team. Participation in this study is completely voluntary and lack of participation will in no way affect your status on the team or the quality of care that you would receive by the therapy staff if you are injured or being treated in the Varsity Therapy Clinic. If you are injured during the season, Jessica's role as Varsity Athletic Therapist will take precedence over the research role, and all injuries (including concussions) will be managed as per UOIT medical policy and procedure.

Because Jessica will be given your personal information once you agree to participate in Phase 2 of the study, you may feel uncomfortable or embarrassed by certain responses that you gave. You are able to ask that any response you give be removed from the interview transcript, or you may choose to withdraw from the study at any point. Jessica is bound by ethical requirements as a Certified Athletic Therapist to maintain confidentiality about all information provided, and UOIT research and scope of practice guidelines further dictate that your responses could not be used to affect your status as an athlete or patient in the Varsity Therapy Clinic. Please note, there are two other Certified Athletic Therapists and various Student Therapists who are available to assess and treat injuries in the Varsity Therapy Clinic, so if you require treatment for an injury and you are not comfortable dealing with Jessica, you are free to utilize the services of a different therapist.

UOIT has counselling services available to all students and may be contacted if you experience any discomfort or embarassment after you have completed your interview session. Registered mental health professionals are available to speak to you using the following contact information:

Student Mental Health Services: 905.721.3392 or studentlifeline@uoit.ca

Location:UOIT Student Life

- **North Oshawa location:** U5 Building
- **Downtown Oshawa location:** 61 Charles Street Building, Room 225 (by appointment only)
- Hours: Monday to Friday, 8:30 a.m. to 4:30 p.m.

6) Storage of Data

The audio recordings of the interviews, paper questionnaires and hand written or typed notes from the interview sessions will be stored in a secure location in the principal investigator's (Jessica Salt) office for 7 years after the completion of the study. There will be no personal identifiers associated with any of these documents or recordings. Electronic information (interview transcripts) will be stored on a password protected external hard drive in the same location, for the same duration of time.

Any identifying documents (e.g. the information page from the initial questionnaire, emails between research assistants/Jessica Salt and participants) will be destroyed by the principal investigator upon completion of the study.

7) Confidentiality

All interview responses will remain confidential and will not be stored with any identifiers. The interviews will be transcribed by the principal investigator or transcription service (using a confidentiality agreement), and all identifiers will be removed from the transcript. You will be referred in all papers, presentations, and correspondence using a code and no identifying features will be used.

When the interview process is complete, the demographic information completed in Phase 1 of the study will be destroyed.

In no way will your responses in the interviews affect your medical treatment in the Varsity Therapy Clinic or future participation as a varsity athlete.

8) Right to Withdraw

You are free to withdraw from the study at any time without prejudice. There will be no personal consequences associated with the withdrawal. If you wish to withdraw from this study, simply tell the researcher/examiner that you no longer wish to participate. If you do choose to withdraw, your data will not be used for study purposes.

If you decide to withdraw from the study, your status as a varsity athlete or type or quality medical care in the Varsity Therapy Clinic will not be affected.

9) Debriefing and Dissemination of Results

The data from this research may be submitted to scientific conferences and peer reviewed journals. All published data will be coded so that your data is not identifiable. At your request, and at the completion of this study, you will be sent a summary of the research findings. You are also free to meet with Jessica Salt upon completion of the study to learn about the findings and conclusions reached by the study.

10) Thank You

Jessica Salt and the research assistants would like to thank you in advance for your participation in Phase 2 of this study. Your time and contribution is much appreciated and your responses will contribute valuable information toward this research. We understand that your time is valuable and you have taken time to participate in this study so we thank you for this as well.

11) Questions

Thank you very much for your time and for making this study possible. If you have any questions or wish to know more please contact:

Jessica Salt CAT(C) BSc Kin Dip SIM
Certified Athletic Therapist, UOIT Varsity Athletic Therapist & Graduate Student
University of Ontario Institute of Technology
Faculty of Health Sciences
2000 Simcoe St. North
Oshawa, Ontario L1H 7K4
Phone: (905) 721-8668 ext. 2156
Email: Jessica.Salt@uoit.ca

You can also contact the faculty supervisor on this project, if you have any further questions.

Dr. Bernadette Murphy, Professor, Faculty of Health Sciences,
University of Ontario Institute of Technology
2000 Simcoe St. North, Oshawa, ON L1H 7K4
Phone: (905) 449-7053, Email: Bernadette.murphy@uoit.ca

For any other queries regarding this study, please contact the UOIT Research and Ethics Committee Compliance officer (compliance@uoit.ca and 905-721-8668 ext. 3693).

Upon arrival at the interview session, you will have an opportunity to review this form again and discuss with the researcher any concerns that you may have

Signature Page

Please read the following before signing the consent form and remember to keep a copy for your own records.

To be filled out and signed by the participant. Please check as appropriate.

I have read the consent.	Yes { } No { }
I have had the opportunity to ask questions/to discuss this study.	Yes { } No { }
I have received satisfactory answers to all of my questions.	Yes { } No { }
I have received enough information about the study.	Yes { } No { }
I understand that I am free to withdraw from the study	Yes { } No { }

- at any time
- without having to give a reason
- without prejudice

I understand that it is my choice to be in the study	Yes { } No { }
I agree to take part in this study.	Yes { } No { }
I give consent for my data to be used in papers or presentations with all identifying information removed	Yes { } No { }

_____ _____

Signature of participant Date

_____ _____

Signature of witness Date

Signing this form gives us your consent to be in this study. It tells us that you understand the information about the research study. When you sign this form, you do not give up your legal rights. Researchers or agencies involved in this research study still have their legal and professional responsibilities.

To be signed by the investigator:

I have explained this study to the best of my ability. I invited questions and gave answers. I believe that the participant fully understands what is involved in being in the study, any potential risks of the study and that he or she has freely chosen to be in the study.

_____ _____

Signature of investigator Date

Appendix F - UOIT Varsity Athlete Demographic & Information Questionnaire

UOIT Varsity Athlete Demographic & Information Questionnaire

Thank you for your participation in this study. If you have any questions or concerns please contact the lead investigator, Jessica Salt, at Jessica.Salt@uoit.ca or (905)721-8668 ext.2156.

Name: _____ Sex: M F

Email Address: _____

Date of Birth: mm/dd/yy ___/___/_____

Sport: _____

Position: _____

Years Playing Your Sport: _____

Varsity Eligibility Year: _____

All Athletes:

PLEASE READ AND ANSWER **ALL** QUESTIONS (RESPONSES WILL NOT BE READ UNTIL AFTER THE FALL VARSITY SEASON):

1.	Are you currently taking any medications or using recreational drugs?	YES	NO
2.	Are you currently being treated (by a Physiotherapist/ Chiropractor/ RMT/ Athletic Therapist/Etc.) for a head or neck injury (including concussion)?	YES	NO
3.	Did you drink more than 2 alcoholic beverages in the last 24 hours?	YES	NO
4.	Did you have less than 5 hours of sleep last night?	YES	NO
5.	Have you received education on concussion recognition and treatment?	YES	NO

All Athletes:

PLEASE READ THE FOLLOWING STATEMENTS. PLEASE CIRCLE YES IF THE FOLLOWING HAS OCCURRED TO YOU IN THE LAST YEAR, AND CIRCLE NO IF IT HAS NOT OCCURRED TO YOU IN THE LAST YEAR

	YES	NO
Dizziness after an impact to my body, head, or neck	Y	N
Saw stars after an impact	Y	N
Lost consciousness or blacked out after an impact	Y	N
Forgot what to do on the field/ice after an impact	Y	N
Had problems studying, concentrating or doing class work after an impact	Y	N
Had a headache at least once during the week after an impact	Y	N
Had my "bell rung"	Y	N
Vomited or felt nauseous after an impact	Y	N
Experienced strange symptoms after an impact but did not tell the coach or therapy staff (kept on playing/practicing)	Y	N
Continued to experience any strange symptoms after an impact and kept on playing	Y	N
Continued to experience any of these symptoms the day after a hit but did not tell a coach or Athletic Therapist	Y	N
Behaved differently than normal with friends or family	Y	N
Had difficulty making decisions or choices during every day activities	Y	N
Been more aggressive or emotional than normal	Y	N

IN THE LAST YEAR, HAVE YOU EXPERIENCED ANY OF THE FOLLOWING SYMPTOMS AFTER A BLOW TO THE HEAD, NECK OR BODY, OR AFTER A FALL? IF YES, HOW SEVERE WERE THE SYMPTOMS?

	N/A	Mild		Moderate		Severe	
Headache	0	1	2	3	4	5	6
“Pressure in head”	0	1	2	3	4	5	6
Neck Pain	0	1	2	3	4	5	6
Nausea or vomiting	0	1	2	3	4	5	6
Blurred vision	0	1	2	3	4	5	6
Balance problems	0	1	2	3	4	5	6
Sensitivity to light	0	1	2	3	4	5	6
Sensitivity to noise	0	1	2	3	4	5	6
Feeling slowed down	0	1	2	3	4	5	6
Feeling “in a fog”	0	1	2	3	4	5	6
“Don’t feel right”	0	1	2	3	4	5	6
Difficulty concentrating	0	1	2	3	4	5	6
Difficulty remembering	0	1	2	3	4	5	6
Fatigue or low energy	0	1	2	3	4	5	6
Confusion	0	1	2	3	4	5	6
Drowsiness	0	1	2	3	4	5	6
Trouble falling asleep	0	1	2	3	4	5	6
More emotional	0	1	2	3	4	5	6
Irritability	0	1	2	3	4	5	6
Sadness	0	1	2	3	4	5	6
Nervous or anxious	0	1	2	3	4	5	6

Returning Varsity Athletes:

1.	Since the start of last varsity season have you hit your head, been in a car accident, or had a major fall?	YES	NO
2.	In the last varsity season, did you experience a headache during physical activity (including practices or games)?	YES	NO
	If yes to Question 2, did you report it to the coach or medical staff?	YES	NO
3.	Since the start of the last varsity season, have you been diagnosed with a concussion?	YES	NO
	If yes to Question 3, how long did you experience symptoms? _____ days		
	If yes to Question 3, how many days of games/practices did you miss? _____ days		
	If yes to Question 3, how many days of class did you miss? _____ days		
4.	Since the start of last varsity season, do you **think** that you might have suffered a concussion?	YES	NO
5.	How many concussions have you been **diagnosed** with in your life? _____ concussions		
6.	How many concussions do you **think** you have had in your life? _____ concussions		

Freshman/Rookie Varsity Athletes:

1.	In the last year, have you hit your head, been in a car accident, or had a major fall?	YES	NO
2.	In the last year, did you experience a headache during physical activity (including practices or games)?	YES	NO
	If yes to Question 2, did you report it to your coach, parent, or medical staff?	YES	NO
3.	In the last year, have you been **diagnosed** with a concussion?	YES	NO
	If yes to Question 3, how long did you experience symptoms? _____ days		
	If yes to Question 3, how many days of games/practices did you miss? _____ days		
	If yes to Question 3, how many days of class did you miss? _____ days		
4.	In the last year, do you **think** that you might have suffered a concussion?	YES	NO
5.	How many concussions have you been **diagnosed** with in your life? _____ concussions		
6.	How many concussions do you **think** you have had in your life? _____ concussions		

Appendix G – Phase 1 Questionnaire

UOIT Varsity Athlete Phase 1 Questionnaire

Thank you for your participation in this study. If you have any questions or concerns please contact the lead investigator, Jessica Salt, at Jessica.Salt@uoit.ca or (905)721-8668 ext.2156, or your research assistant.

Name: _____

Email Address: _____

Date of Birth: mm/dd/yy ___/___/_____

Section 1

DIRECTIONS: PLEASE READ THE FOLLOWING STATEMENTS AND CIRCLE TRUE OR FALSE FOR EACH QUESTION.

1.	There is a possible risk of death if a second concussion occurs before the first one has healed.	TRUE	FALSE
2.	Running every day does little to improve cardiovascular health.	TRUE	FALSE
3.	People who have had one concussion are more likely to have another concussion.	TRUE	FALSE
4.	Cleats help athletes' feet grip the playing surface.	TRUE	FALSE
5.	In order to be diagnosed with a concussion, you have to be knocked out.	TRUE	FALSE
6.	A concussion can only occur if there is a direct hit to the head.	TRUE	FALSE
7.	Being knocked unconscious always causes permanent damage to the brain.	TRUE	FALSE
8.	Symptoms of a concussion can last for several weeks.	TRUE	FALSE
9.	Sometimes a second concussion can help a person remember things that were forgotten after the first concussion.	TRUE	FALSE
10.	Weightlifting helps tone and/or build muscle.	TRUE	FALSE
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.	TRUE	FALSE
12.	If you receive one concussion and you have never had a concussion before, you will become less intelligent.	TRUE	FALSE
13.	After 10 days, symptoms of a concussion are usually completely gone.	TRUE	FALSE
14.	After a concussion, people can forget who they are and not recognize others but be perfect in every other way.	TRUE	FALSE
15.	High-school freshmen and college freshmen tend to be the same age.	TRUE	FALSE
16.	Concussions can sometimes lead to emotional disruptions.	TRUE	FALSE
17.	An athlete who gets knocked out after getting a concussion is experiencing a coma.	TRUE	FALSE
18.	There is rarely a risk to long-term health and well-being from multiple concussions.	TRUE	FALSE

Section 2

DIRECTIONS: PLEASE READ THE FOLLOWING SCENARIOS AND CIRCLE TRUE OR FALSE FOR EACH QUESTION THAT FOLLOWS THE SCENARIOS.

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.			
1.	It is more likely that Player Q's concussion will affect his long-term health and well-being	TRUE	FALSE
2.	It is more likely that Player X's concussion will affect his long-term health and well-being	TRUE	FALSE
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.			
3.	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.	TRUE	FALSE

Section 3

DIRECTIONS: FOR EACH QUESTION CIRCLE THE NUMBER THAT BEST DESCRIBES HOW YOU FEEL ABOUT EACH STATEMENT.

		Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
1.	I would continue playing a sport while also having a headache that resulted from a minor concussion.	1	2	3	4	5
2.	I feel that coaches need to be extremely cautious when determining whether an athlete should return to play.	1	2	3	4	5
3.	I feel that mouthguards protect teeth from being damaged or knocked out.	1	2	3	4	5
4.	I feel that professional athletes are more skilled at their sport than high-school athletes.	1	2	3	4	5
5.	I feel that concussions are less important than other injuries.	1	2	3	4	5
6.	I feel that an athlete has a responsibility to return to a game even if it means playing while still experiencing symptoms of a concussion.	1	2	3	4	5
7.	I feel that an athlete who is knocked unconscious should be taken to the emergency room.	1	2	3	4	5
8.	I feel that most university athletes will play professional sports in the future.	1	2	3	4	5

Section 4

DIRECTIONS: FOR EACH QUESTION READ THE SCENARIOS AND CIRCLE THE NUMBER THAT BEST DESCRIBES YOUR VIEW. (FOR THE QUESTIONS THAT ASK YOU WHAT *MOST ATHLETES* FEEL, BASE YOUR ANSWERS ON HOW YOU THINK MOST ATHLETES WOULD FEEL.)

		Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
SCENARIO 1						
Player R suffers a concussion during a game. Coach A decides to keep Player R out of the game, Player R's team loses the game.						
1.	I feel that Coach A made the right decision to keep Player R out of the game.	1	2	3	4	5
2.	Most athletes would feel that Coach A made the right decision to keep Player R out of the game.	1	2	3	4	5
SCENARIO 2						
Athlete M suffered a concussion during the first game of the season. Athlete O suffered a concussion of the same severity during the semifinal playoff game. Both athletes had persisting symptoms.						
3.	I feel that Athlete M should have returned to play during the first game of the season.	1	2	3	4	5
4.	Most athletes would feel that Athlete M should have returned to play during the first game of the season.	1	2	3	4	5
5.	I feel that Athlete O should have returned to play during the semifinal playoff game.	1	2	3	4	5
6.	Most athletes would feel that Athlete O should have returned to play during the semifinal playoff game.	1	2	3	4	5
SCENARIO 3						
Athlete R suffered a concussion. Athlete R's team has an Athletic Trainer on the staff.						
7.	I feel that the Athletic Trainer, rather than Athlete R, should make the decision about returning Athlete R to play.	1	2	3	4	5
8.	Most athletes would feel that the Athletic Trainer, rather than Athlete R, should make the decision about returning Athlete R to play.	1	2	3	4	5
SCENARIO 4						
Athlete H suffered a concussion and he has a game in 2 hours. He is still experiencing symptoms of concussion. However, Athlete H knows that if he tells his coach about the symptoms, his coach will keep him out of the game						
9.	I feel that Athlete H should tell his coach about the symptoms.	1	2	3	4	5
10.	Most athletes would feel that Athlete H should tell his coach about the symptoms.	1	2	3	4	5

Section 5

DIRECTIONS: THINK ABOUT SOMEONE WHO HAS HAD A CONCUSSION. CHECK OFF THE FOLLOWING SIGNS AND SYMPTOMS THAT YOU BELIEVE SOMEONE MAY BE LIKELY TO EXPERIENCE AFTER A CONCUSSION.

Hives	Y	N	Feeling in a "Fog"	Y	N
Headache	Y	N	Weight Gain	Y	N
Difficulty Speaking	Y	N	Feeling Slowed Down	Y	N
Arthritis	Y	N	Reduced Breathing Rate	Y	N
Sensitivity to Light	Y	N	Excessive Studying	Y	N
Difficulty Remembering	Y	N	Difficulty Concentrating	Y	N
Panic Attacks	Y	N	Dizziness	Y	N
Drowsiness	Y	N	Hair Loss	Y	N

Section 6

DIRECTIONS: PLEASE RATE HOW STRONGLY YOU AGREE WITH EACH STATEMENT:

		Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
1.	If I report what I suspect might be a concussion, I will hurt my team's performance	1	2	3	4	5
2.	If I report what I think might be a concussion, I will not be allowed to start playing or practicing when I think I'm ready	1	2	3	4	5
3.	If I report what I suspect might be a concussion, I will lose my spot in the lineup.	1	2	3	4	5
4.	If I report what I suspect might be a concussion, my teammates will think less of me	1	2	3	4	5
5.	The sooner I report a concussion, the sooner I'll be back at full strength	1	2	3	4	5
6.	If I report what I suspect might be a concussion, I will be held out of an upcoming game even if it is *not* a concussion	1	2	3	4	5
7.	If I report what I suspect might be a concussion, my teammates will think I made the right decision.	1	2	3	4	5
8.	If I report what I suspect might be a concussion, I will be better off in the long run	1	2	3	4	5
9.	I am confident in my ability to recognize when I have symptoms of a concussion	1	2	3	4	5
10.	I am confident in my ability to report symptoms of a concussion, even when I really want to keep playing	1	2	3	4	5
11.	I am confident in my ability to report symptoms of a concussion, even when I think my teammates want me to play	1	2	3	4	5
12.	I am confident in my ability to report symptoms of a concussion, even if I don't think they are that bad	1	2	3	4	5
13.	I am confident in my ability to report specific symptoms, even if I am not sure that it is actually a concussion	1	2	3	4	5
14.	I would continue playing a sport while also having a headache resulting from a concussion	1	2	3	4	5
15.	I would tell the therapist if I thought a teammate had a concussion	1	2	3	4	5

Section 7

DIRECTIONS: THESE QUESTIONS CONTAIN STATEMENTS ABOUT CONCUSSIONS THAT MAY OR MAY NOT BE TRUE. PLEASE RATE HOW STRONGLY YOU AGREE WITH EACH STATEMENT.

		Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
1.	People who have had a concussion are more likely to have another concussion.	1	2	3	4	5
2.	There is a possible risk of death if a second concussion occurs before the first one has healed.	1	2	3	4	5
3.	A concussion cannot cause brain damage unless the person has been knocked out.	1	2	3	4	5
4.	The brain never fully heals after a concussion.	1	2	3	4	5
5.	It is easy to tell if a person has a concussion by the way the person looks or acts.	1	2	3	4	5
6.	Symptoms of a concussion can last for several weeks.	1	2	3	4	5
7.	Resting your brain by avoiding things such as playing video games, texting, and doing schoolwork is important for concussion recovery.	1	2	3	4	5
8.	After a concussion occurs, brain imaging (e.g., computer assisted tomography scan, magnetic resonance imaging, X-ray, etc.) typically shows visible physical damage to the brain (e.g., bruise, blood clot).	1	2	3	4	5
9.	A concussion may cause an athlete to feel depressed or sad.	1	2	3	4	5
10.	Once an athlete feels “back to normal”, the recovery process is complete.	1	2	3	4	5
11.	Even if a player is experiencing the effects of a concussion, performance on the field will be the same as it would have been had the player not experienced a concussion.	1	2	3	4	5
12.	Concussions pose a risk to an athletes’ long-term health and well-being.	1	2	3	4	5
13.	A concussion can only occur if there is a direct hit to the head.	1	2	3	4	5

Section 8

DIRECTIONS: PLEASE RATE HOW STRONGLY YOU AGREE WITH THE FOLLOWING STATEMENT:

"I would stop playing and report my symptoms if I sustained an impact that caused me to…"

		STRONGLY DISAGREE	DISAGREE	NEUTRAL	AGREE	STRONGLY AGREE
1.	See stars	1	2	3	4	5
2.	Vomit or feel nauseous	1	2	3	4	5
3.	Have a hard time remembering things	1	2	3	4	5
4.	Have a hard time concentrating in class or on homework	1	2	3	4	5
5.	Feel sensitive to light or noise	1	2	3	4	5
6.	Have a headache	1	2	3	4	5
7.	Experience dizziness or balance problems	1	2	3	4	5
8.	Feel sleepy or "in a fog"	1	2	3	4	5

Thank you for your participation in this study. If you have any questions or concerns please contact the lead investigator, Jessica Salt, at Jessica.Salt@uoit.ca or (905)721-8668 ext.2156 or the research assistant at the contact information provided.

Appendix H – Phase 2 Questionnaire

UOIT Varsity Athlete Phase 2 Questionnaire

Thank you for your participation in this study. If you have any questions or concerns please contact the lead investigator, Jessica Salt, at Jessica.Salt@uoit.ca or (905)721-8668 ext.2156, or the research assistant.

Name: _____

Email Address: _____

Date of Birth: mm/dd/yy ___/___/_____

Section 1

PLEASE READ AND ANSWER **ALL** QUESTIONS:

1.	Are you currently taking any medications or using recreational drugs?	YES	NO
2.	Are you currently being treated (by a Physiotherapist/ Chiropractor/ RMT/ Athletic Therapist/Etc.) for a head or neck injury (including concussion)?	YES	NO
3.	Did you drink more than 2 alcoholic beverages in the last 24 hours?	YES	NO
4.	Did you have less than 5 hours of sleep last night?	YES	NO
5.	Have you received education on concussion recognition and treatment?	YES	NO
6.	Since the start of this varsity season have you hit your head, been in a car accident, or had a major fall?	YES	NO
7.	In this varsity season, did you experience any symptoms during physical activity that you thought might have been from a concussion (including practices or games)?	YES	NO
	If yes to Question 7, did you report it to the coach or medical staff?	YES	NO
8.	Since the start of this varsity season, have you been diagnosed with a concussion?	YES	NO
	If yes to Question 8, how long did you experience symptoms? _____ days		
	If yes to Question 8, how many days of games/practices did you miss? _____ days		
	If yes to Question 8, how many days of class did you miss? _____ days		
9.	Since the start of this varsity season, do you **think** that you might have suffered a concussion?	YES	NO
10.	How many concussions have you been **diagnosed** with in your life? _____ concussions		
11.	How many concussions do you **think** you have had in your life? _____ concussions		

Section 2

IN THIS VARSITY SEASON, HAVE YOU EXPERIENCED ANY OF THE FOLLOWING SYMPTOMS AFTER A BLOW TO THE HEAD, NECK OR BODY, OR AFTER A FALL? IF YES, HOW SEVERE WERE THE SYMPTOMS?

	N/A	Mild		Moderate		Severe	
Headache	0	1	2	3	4	5	6
"Pressure in head"	0	1	2	3	4	5	6
Neck Pain	0	1	2	3	4	5	6
Nausea or vomiting	0	1	2	3	4	5	6
Blurred vision	0	1	2	3	4	5	6
Balance problems	0	1	2	3	4	5	6
Sensitivity to light	0	1	2	3	4	5	6
Sensitivity to noise	0	1	2	3	4	5	6
Feeling slowed down	0	1	2	3	4	5	6
Feeling "in a fog"	0	1	2	3	4	5	6
"Don't feel right"	0	1	2	3	4	5	6
Difficulty concentrating	0	1	2	3	4	5	6
Difficulty remembering	0	1	2	3	4	5	6
Fatigue or low energy	0	1	2	3	4	5	6
Confusion	0	1	2	3	4	5	6
Drowsiness	0	1	2	3	4	5	6
Trouble falling asleep	0	1	2	3	4	5	6
More emotional	0	1	2	3	4	5	6
Irritability	0	1	2	3	4	5	6
Sadness	0	1	2	3	4	5	6
Nervous or anxious	0	1	2	3	4	5	6

Section 3

PLEASE READ THE FOLLOWING STATEMENTS. PLEASE CIRCLE YES IF THE FOLLOWING HAS OCCURRED TO YOU IN THIS VARSITY SEASON, AND CIRCLE NO IF IT HAS NOT OCCURRED TO YOU IN THIS VARSITY SEASON.

Dizziness after an impact to my body, head, or neck	YES	NO
Saw stars after an impact	YES	NO
Lost consciousness or blacked out after an impact	YES	NO
Forgot what to do on the field/ice after an impact	YES	NO
Had problems studying, concentrating or doing class work after an impact	YES	NO
Had a headache at least once during the week after an impact	YES	NO
Had my "bell rung"	YES	NO
Vomited or felt nauseous after an impact	YES	NO
Experienced strange symptoms after an impact but did not tell the coach or therapy staff (kept on playing/practicing)	YES	NO
Continued to experience any strange symptoms after an impact and kept on playing	YES	NO
Continued to experience any of these symptoms the day after a hit but did not tell a coach or Athletic Therapist	YES	NO
Behaved differently than normal with friends or family	YES	NO
Had difficulty making decisions or choices during every day activities	YES	NO
Been more aggressive or emotional than normal	YES	NO

Section 4

DIRECTIONS: FOR EACH QUESTION CIRCLE THE NUMBER THAT BEST DESCRIBES HOW YOU FEEL ABOUT EACH STATEMENT.

		Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
1.	I would continue playing a sport while also having a headache that resulted from a minor concussion.	1	2	3	4	5
2.	I feel that coaches need to be extremely cautious when determining whether an athlete should return to play.	1	2	3	4	5
3.	I feel that mouthguards protect teeth from being damaged or knocked out.	1	2	3	4	5
4.	I feel that professional athletes are more skilled at their sport than high-school athletes.	1	2	3	4	5
5.	I feel that concussions are less important than other injuries.	1	2	3	4	5
6.	I feel that an athlete has a responsibility to return to a game even if it means playing while still experiencing symptoms of a concussion.	1	2	3	4	5
7.	I feel that an athlete who is knocked unconscious should be taken to the emergency room.	1	2	3	4	5
8.	I feel that most university athletes will play professional sports in the future.	1	2	3	4	5

Section 5

DIRECTIONS: Please rate how strongly you agree with each statement:

		Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
1.	If I report what I suspect might be a concussion, I will hurt my team's performance	1	2	3	4	5
2.	If I report what I think might be a concussion, I will not be allowed to start playing or practicing when I think I'm ready	1	2	3	4	5
3.	If I report what I suspect might be a concussion, I will lose my spot in the lineup.	1	2	3	4	5
4.	If I report what I suspect might be a concussion, my teammates will think less of me	1	2	3	4	5
5.	The sooner I report a concussion, the sooner I'll be back at full strength	1	2	3	4	5
6.	If I report what I suspect might be a concussion, I will be held out of an upcoming game even if it is *not* a concussion	1	2	3	4	5
7.	If I report what I suspect might be a concussion, my teammates will think I made the right decision.	1	2	3	4	5
8.	If I report what I suspect might be a concussion, I will be better off in the long run	1	2	3	4	5
9.	I am confident in my ability to recognize when I have symptoms of a concussion	1	2	3	4	5
10.	I am confident in my ability to report symptoms of a concussion, even when I really want to keep playing	1	2	3	4	5
11.	I am confident in my ability to report symptoms of a concussion, even when I think my teammates want me to play	1	2	3	4	5
12.	I am confident in my ability to report symptoms of a concussion, even if I don't think they are that bad	1	2	3	4	5
13.	I am confident in my ability to report specific symptoms, even if I am not sure that it is actually a concussion	1	2	3	4	5
14.	I would continue playing a sport while also having a headache resulting from a concussion	1	2	3	4	5
15.	I would tell the therapist if I thought a teammate had a concussion	1	2	3	4	5

Section 6

DIRECTIONS: PLEASE RATE HOW STRONGLY YOU AGREE WITH THE FOLLOWING STATEMENT:

"I would stop playing and report my symptoms if I sustained an impact that caused me to…"

		STRONGLY DISAGREE	DISAGREE	NEUTRAL	AGREE	STRONGLY AGREE
1.	See stars	1	2	3	4	5
2.	Vomit or feel nauseous	1	2	3	4	5
3.	Have a hard time remembering things	1	2	3	4	5
4.	Have a hard time concentrating in class or on homework	1	2	3	4	5
5.	Feel sensitive to light or noise	1	2	3	4	5
6.	Have a headache	1	2	3	4	5
7.	Experience dizziness or balance problems	1	2	3	4	5
8.	Feel sleepy or "in a fog"	1	2	3	4	5

Section 7

PLEASE READ AND ANSWER **YES OR NO**:

1.	Do you believe that your responses on the first set of questionnaires (at the start of the season) were kept anonymous from the principal investigator?	YES	NO
2.	If not, did this affect the way you answered the questions?	YES	NO

Thank you for your participation in this study. If you have any questions or concerns please contact the lead investigator, Jessica Salt, at Jessica.Salt@dc-uoit.ca or (905)721-2000 ext.2156 or the research assistant at the contact information provided.

Appendix I – Semi-Structured Interview Guide

Semi-Structured Interview Guide – Concussion symptom reporting in varsity athletes

1. **Introduction:** **5 – 10 minutes**

   a) Review informed consent prior to taping. Ask if they have any questions about the reason for, or content of, the informed consent.
   b) Set the stage and purpose for the session. The purpose of the interview is to obtain participants' perspective and experiences on matters related to concussions and symptom reporting; in particular factors influencing their opinions (teammates, coaches, media), specific experiences and knowledge (prior education, experience).
   c) There are some set questions, but this is an opportunity for a conversation and discussion about opinions and experiences, so we do not have to adhere directly to the script if there are important and relevant ideas and concepts raised.
   d) Interviewer relates own experiences with concussions, and difficulties experienced after concussion. Opens up discussion to allow for personal interaction.

2. **Content Questions:** **45-55 minutes**

All Athletes:

a) Let's begin with briefly identifying how long you've been playing *** and if you've had any injuries, in particular concussions.
   i. What is top of mind when you think about concussions, and in particular, your experience?

b) For those with concussion and other injury – which do you feel was worse?

Non- Concussed:

You didn't report any concussions this varsity season. Do you think you have experienced a concussion prior to this season?
Did you experience any blows to the head?

- Yes –
  - Did you experience any symptoms?
  - If yes, can you describe them?
  - Did you think about a concussion at the time?
  - In retrospect, do you think it may have been a concussion?
- No – What makes you think so? Can you discuss your experience?

- Did you experience any blows to the head this season?

Concussed:

Report:

- You reported a concussion to medical staff this season. Describe in as much detail as you can, what happened that caused your concussion. What led you to reporting the symptoms? (probe: did on-field med staff assess and ask questions? Was this assessment done on the field, off the field, during or post game? Did participant follow-up with another provider after the game to assess symptoms?
- What were the consequences of reporting your symptoms?
- If the same situation were to happen again in the future, what would you do?
- Would you do anything differently? e.g. not report but monitor symptoms; report symptoms faster, etc.
    - Yes: why?
    - No: Why not?
        - What is the threshold you would have to decide to report your symptoms?
    - What stands out with your experience?

- Can you think of anything that would change your decision to report your symptoms? (probe: severity, certain symptoms)

Non-Report:

- You reported having symptoms that may have been from a concussion in your second survey.
    - From what you know about concussions, do you think you might have had a concussion?
    - Could you talk about what made you decide not to report them to medical staff?
    - Did you tell anyone about your symptoms?
        - If so, why? When?
- What do you think would have happened if you had reported your symptoms?
    - What led you to believe that *** would happen?
- What is the threshold you would have to decide to report your symptoms?

Previous Concussions:

You have a history of previous concussions, can you tell me about the experience?

What happened?

Who did you go to for diagnosis? Assessment?

What happened after you were diagnosed? Probe: missed games/practices, return to play plan

- How does that compare to this latest one?
- For those with concussion this season - Did that experience affect your decision to report/not report?

Do you think your history of concussions could influence you reporting your symptoms in the future? Probe deeper depending upon response.

No Previous Concussions:

Based on what you know about concussions, do you think you may have experienced symptoms consistent with concussion in your past?

i. Why/why not?
ii. What has changed in your understanding or experience that makes you think you may have been concussed?
iii. Given your response, would you do anything differently today?

All Athletes:

c) Do you have any friends or teammates who have had concussions?

d) Do you think concussions are a serious issue for athletes?
   i. Why is it important/not important?
   ii. Should concussions in student-athletes be treated differently than for pro athletes, or higher-level athletes (e.g. Olympians, those who might become pro)

e) How common do you feel concussions are in athletes? (probe: based on what experience)

f) What type of concussion education have you received during your athletic career?
   i. Did it affect your opinion about concussions?
   ii. Did it provide you guidance on how to manage symptoms? When to report? etc.

g) Do you believe all concussions should be reported? If so, why, to whom, when, etc. If not, why? What are some of the consequences of failing to report concussive symptoms?

h) What are some of the consequences of reporting concussive symptoms? (probe: playing time, missed training, classes)

i) What impact does the situation play in making the decision to report? (probe: games, practices, in season, out of season)

j) What role should your coach play in your decision to report?

k) What role should your teammates play in your decision to report?

l) Would you report a teammate's concussion if you suspect they may have had it or you knew they did?
    i. Who would you tell?

m) Do you have anything else you would like to add that we haven't had an opportunity to talk about up to now?

3. **Debrief –**
    a. Allow the participant to ask any questions regarding the study, or open the conversation to other topics as needed
    b. Ensure that the participant is comfortable with their responses – remind him/her that answers can be removed from the transcript or interviewer can be contacted at a later date to update any responses
    c. Remind participant of counselling services available on campus if needed
    d. Tell participant that he/she will obtain a copy of the transcribed interview for review, and he/she may choose to update any responses or request a follow-up session with the principal investigator

4. **Conclusion**
    Thank You

Appendix J – Interview Code Definitions

Interview Code Definitions

Age – Changes in attitude toward concussion reporting and experience with concussion as the participant ages. Maturity, more life experience, increased knowledge

Awareness of Deficits – Athletes' awareness of changes in personality, playing ability and cognitive declines (e.g. memory). Can be recognized after recovery, or at the time of injury by the injured athlete or others.

Common Injury – Athletes' perception of how common concussions are… based on personal experience, experience of others, and social messages

Decision to Report – The factors involved with the individual's decision to report concussive symptoms.

Desire to Play – Athletes' internal drive to play

Duration of Symptoms – How long signs and symptoms lasted for concussions experienced by participant

Education – The formal or informal teaching of concussion signs and symptoms received by the participant.

Experience of Others – Others who the participant knows or has heard of who have experienced concussions. Participants learn from the experience of others and relate those to their own experience.

- Friends, Teammates, Rowan Stringer, Media, Previous Men's Hockey Coach

Effect on School – the effect of past or current (this season) concussions on academic performance (self-determined or objectively through actual grades)

Invisible Injury – Other's cannot see outward signs of a concussion, therefore may be perceived differently than an obvious musculoskeletal (MSK) injury

Justification – ability/awareness (or lack of) how to apply meaning to signs and symptoms of concussion

Knowledge – The level of understanding and awareness of concussion signs and symptoms of the participant. Related to education but related more to the internalizing and understanding of the signs and symptoms – not just the receiving of education.

Lack of Control – Athletes with concussion are unable to control the return to play process and cannot return when they feel better. Are pulled out of sport, school and social networks by others and cannot re-engage until permitted by others. Minimal treatment options are available, so there is little they perceive they can do to speed up their healing.

Legitimization of Signs and Symptoms – When others acknowledge or understand S/S described by the athlete, may increase disclosure/honesty about symptoms

Long Term Consequences – Athletes' understanding of view of the long term consequences of either their concussion or concussions in general

Meaning to Symptoms – How participants ascribe meaning or understanding to signs and symptoms experienced when concussed

Parental Involvement – How parents responded to previous injuries and concussions, messaging received when growing up

Personal Experience – Experience of the participant with previous or current (this season) concussions or MSK injuries – recovery time, symptoms experienced, perceived consequences

Pressure: External –People/situations that athletes' perceive place pressure on them to continue playing/return to play early/not report.

- Coaches, Teammates, Parents, Media/Society

Pressure: Internal – The intrinsic values and messaging that participants use to explain/justify playing through pain or injury.

Previous Concussions – The number of previous concussions experienced by the participant

Previous Injury – Other MSK injuries the participants have experienced. Can use them as a comparison when relating seriousness of concussion as a sport injury

Reporting on Teammate – Threshold or process the participant would go through to decide to report a teammates' concussion to staff

Reporting Threshold – The sign or symptom that the participant would have to be experiencing in order to report a concussion to staff. Also relates to the length of time the individual experiences the sign/symptom before reporting

Return to Play – the process or steps taken to determine when it is safe for an athlete to return to play after an injury

Role of Prior Injury – How participants use their prior experience with MSK injuries and concussion to evaluate the seriousness of new concussion and influence their decision to report

Role on Team – Starter vs. bench player, 1st year, vs upper year, vs final year, leadership role on team
Timing of Injury – When in the season the injury occurs

Seriousness – Opinion of the seriousness of concussion as a sport injury. Relates to comparison with other MSK injuries, long term consequences, effects on ability to play

Severity of Concussion– Athletes' subjective determination of symptom severity of past or current (this season) concussion

Sex – Difference between men's and women's experiences reporting concussion symptoms. Perceived attitude differences between men and women toward the self and others with concussion.

Signs and Symptoms – Objective and subjective physical manifestations of previous/current concussions

Sport Culture/Culture of Risk – Messages received by, and experiences of, athletes that encourage them to play through pain and injury. (Work by Nixon)

Sport Differences – Perceived differences between the sport culture, experiences and expectations of athletes in different sports – relates to concussion, reporting, risk taking behaviour, and relationships with teammates.

Support – External people/groups/organizations participants felt provided positive support throughout their experience of concussion. May be the opposite of "Pressure" code.

Teammates – Effect of teammates on decision to report

Trust – Description of who (healthcare providers, friends, coaches, family) participants place trust in when suffering from a concussion. May relate to return to play decisions, symptom disclosure, or activities of daily living