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Concussion Knowledge of Missoula Youth Hockey Participants and Their Parents

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CONCUSSION KNOWLEDGE OF MISSOULA YOUTH HOCKEY PARTICIPANTS AND THEIR PARENTS.

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This study is designed as part of capturing a larger picture representing concussion knowledge of Missoula youth athletes participating in non-sponsored athletics. The need for this information arose when the current concussion legislation in Montana, the Dylan Steigers Protection of Youth Athletes Act (DSPYAA), underwent review. In efforts to supply the legislators of the Interim Education and Local Government Committee with information about concussion education of athletes in non-sponsored activities, three studies were conducted using Missoula athletes. Alongside youth hockey participants, Missoula youth soccer and Missoula youth football were surveyed.

My thesis reviewed the current literature on concussion prevalence among youth athletes, concussion education of athletes, parents, teachers, and coaches, youth athlete concussion reporting, management of youth concussion, long term consequence of ill-managed concussion, as well as many other aspects of youth athletics and concussion. My thesis surveyed Missoula area youth hockey players and their parents to gain information on their current concussion knowledge. The data was evaluated to provide new information about a population not previously tested. With this data the committee evaluating the DSPYAA evaluated the information collected from this sample to determine if non-sponsored youth athletes need to be included in amendments to the current Montana legislation.

The research was IRB approved with Valerie Moody, Seth Lindauer, and myself as investigators in August 2015. The data was presented as part of House Joint Resolution 26 in April 2016 but amendment to the current legislation was voted down. Following the presentation to the state legislature the survey results were shared with Glacier Ice Rink and the Missoula Area Youth Hockey Association (MAYHA) and they have asked for development of a concussion policy. This policy was developed over Summer and Fall 2016 and implementation of the policy was scheduled for the 2016 winter hockey season. Since this time, the new concussion policy has been successfully implemented at Glacier Ice Rink. Amendment to Montana's current concussion legislation was re-introduced to include non-sponsored youth athletes, House Bill 487, and has passed the Montana House of Representatives and the Senate. It is currently waiting to be signed by Montana governor, Steve Bullock.

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Chapter 1

Introduction

Statement of the Problem:

Concussion, or mild traumatic brain injury (mTBI), persists as one of the most prevalent sports-related injuries in the United States and abroad.[1] Each year, traumatic brain injury accounts for 2.5 million emergency department visits, hospitalizations and deaths in the United states. [1] The CDC estimates there are currently 3.2 to 5.3 million people living with TBI-related disabilities.[1] Specific to sports and recreation related concussion, there may be an estimated 3.8 million reported and unreported concussions in the United States each year.[2] Although money is spent yearly conducting research into investigating better neurocognitive exams, return to play criteria, prevention strategies, and policy and education mandates, concussions continue to be a topic of concern. Without a formula to ensure prevention, health care providers are left providing care via pre-injury education and then, subsequently, post-injury guidance. In efforts to assist in prevention and proper recognition of an mTBI, concussion education mandates have become part of every state's concussion legislation.[3]

A lack of education on signs and symptoms has been shown to contribute to under-reporting among youth athletes, as well as the improper care of an individual with a concussion.[4,5,6] Research efforts, much like this one, have been made to assess the current concussion knowledge levels of athletes, parents, coaches, administrators and others. This research is especially imperative in a state such as Montana that does not include non-sponsored athletics in the state legislation on concussion management. Previous research indicates that concussion knowledge levels lie around the 50% mark, an alarming statistic

when most policies rely on the ability of the athlete, coach and parent to identify symptoms.[7] In Montana alone, less than half of the high schools have a school nurse or athletic trainer to assist in this process.[8] With the current culture of resilience and toughness contributing to strong athlete identity and the lack of education amongst responsible parties, there is much to fear for the future of concussion identification and management.

Theoretical Framework

There are many puzzle pieces that outside supporters and researchers are missing when evaluating the behavioral process of athletes. Alongside many health issues, athletes view concussion as a gray area where the decision making process fails to be black and white.[9] By evaluating concussion knowledge levels for recognition of signs and symptoms and the ability to identify future consequences, a small piece of the puzzle is considered. Here lies the assumption that underreporting by athletes is driven by a lack of symptom-focused knowledge.[10] This idea implies that in an ideal situation the athlete conducts a personal risk assessment based on the knowledge he/she has related to consequences, weighs his/her current physical state against the knowledge he/she has about signs and symptoms, then removes themself from play. Following is a theory that contributes to understanding what an athlete or parent may be considering when thinking about removal from play and how this affects the intervention on behalf of medical personnel.

The Theory of Planned Behavior (TPB) is often used to explain rational decision making, specifically, intention to perform a specific behavior.[10, 11,12,13] The TPB outlines three different components that contribute to intention, and they include: attitude, subjective norms, and perceived behavioral control.[10, 11, 12] The athlete's attitude is

measured as their evaluation of the consequences of performing that behavior.[12] Subjective norms represent perceived pressure, from individuals the athlete respects, to perform a behavior.[12] Perceived behavioral control demonstrates the athlete's evaluation of the ability to perform a behavior.[12]

Previous studies of concussion reporting and injury prevention, while applying the TPB, have revealed some interesting results. One study found that there was a significant association between the perception that reporting symptoms of a concussion will hurt their team's performance and the belief that their teammates will think they made the right decision.[10] In this case, the TPB was used to assess the athlete's attitude and subjective norms. The same study found that two concussion knowledge statements were significantly related to the athlete's intention to report including, a statement asserting the possible risk of death if a second concussion occurs before the first one has healed, and another statement asserting symptoms of a concussion can last for several weeks. This significant association shows that the athlete has critically assessed the consequences of performing a behavior (reporting) based on the future consequences of failing to report.

The most important aspect of the TPB in relation to concussion reporting and injury prevention is attitude.[12] It's been shown that the individuals' attitude toward a behavior is a better predictor of outcome than their attitude toward the objective at which the behavior is focused.[12] This means that an athletes' attitude towards reporting a concussion is more associated with their chosen behavior than the main target, the concussion. Future education on when to report, the signs and symptoms present, and the future consequences if the athlete fails to report have the possibility to influence the current attitude and motivation to learn about concussions.

Purpose of Study (including Rationale):

With a growing focus on mTBI as a contributor to severe long-term health consequences, many organizations and athletic entities have funded efforts to investigate genetic predisposition to long-term effects of concussion, better post-test and return to play guidelines, and prevention techniques. While gains have been made and mTBI has become an injury highlighted in the media, there is still minimal information or guidelines on concussion prevention.[14] Since the myth of helmet design as a method of "prevention" of concussion has been dispelled, many parents are searching for a reinforcing factor as to why it is acceptable for their child to play injury prone sports such as ice hockey and American football.[15] None of these avenues for reassurance will be of assistance if the athletes and parents cannot recognize signs and symptoms of a concussion.

An assessment looking into the implementation of Montana's concussion legislation, the Dylan Steigers Protection of Youth Athletes Act (DSPYAA), spurred a series of studies investigating the implementation of concussion policies across the state.[16] House Joint Resolution 26 (HJ26) outlines the purpose of the assessment as, "WHEREAS, the implementation of any policy requirement for Montana school districts warrants an examination due to the vast differences between our school districts in terms of availability of health care resources, human resources, financial resources, and geography".[17] The all-inclusive assessment of DSPYAA includes recognition of a lack of protection for "non-sponsored" athletic activities. The current legislation covers "Organized youth athletic activity" defined as "an athletic activity sponsored by a school or school district in which the participants are engaged in an athletic game or competition against another team, club or entity, in practice, tryouts, training exercises, or sports camps, or in preparation for an

athletic game or competition against another team, club, or entity".[16] The overseeing committee for HJ26, the Interim Education and Local Government Committee, requested further investigation into the current state of concussion management among sponsored and non-sponsored athletics.

The number of sport-related concussions in children ages 8-13 seen in the emergency department doubled from 1997-2007.[18] An even greater increase, 200%, was seen for the age group 14-19 years old.[18] With a large number of youth athletes participating in sport and a growing concussion rate, attention must be paid to the current state of Montana's youth athletics. Younger athletes have an immature nervous system along with decreased myelination, thinner frontal and temporal bones, a larger head-body ratio, and weaker neck muscles.[19] These characteristics alone, without considering effects of contact sports, leave the youth population in a greater position of danger.

Research was conducted to assess the current concussion knowledge of Missoula Youth Hockey athletes and parents.

Quantitative Research Question(s)

1. Are Missoula youth hockey participants able to identify signs and symptoms of an mTBI?
2. Are Missoula youth hockey parents able to identify signs and symptoms of an mTBI?
3. Are Missoula youth hockey participants able to identify future consequences of a poorly managed concussion?
4. Are Missoula youth parents able to identify future consequences of a poorly managed concussion?

Quantitative Hypothesis

1. Missoula youth hockey participants will be unable to identify all the signs and symptoms of a mTBI.
2. Missoula youth hockey parents will be unable to identify all the signs and symptoms of a mTBI.
3. Missoula youth hockey participants will be unable to identify all the future consequences of a poorly managed concussion.
4. Missoula youth hockey parents will be unable to identify all the future consequences of a poorly managed concussion.

Significance of Study

Knowledge assessments and attitude assessments are frequently used tools in concussion education research.[5,20,21,22,23,24,25] They are often used as a device to assess where the healthcare field, either nationally, state or city, stands in the push for concussion recognition, reporting and proper care. On an essential level, a knowledge assessment can first demonstrate if the group being tested understands the basic components of concussion recognition and how failure to recognize these symptoms may result in extreme consequences. Beyond this, a knowledge assessment and an attitude assessment can provide insight into explanation for continued play or early return to play with symptoms, attitudes and beliefs resulting from environmental factors, fear components during decision making, and risk assessments during decision making.[4,9,26,27]

The significance of this study is rooted in finding out where participants and parents within the Missoula Area Youth Hockey Association fall on the essential level discussed previously. By finding out the concussion knowledge level of Missoula youth hockey

players, some light will be shed on the issue of under-reporting among athletes and the possibility of under-reporting due to lack of knowledge. Current research on concussion education has focused on the connections between lack of knowledge and under-reporting among youth, college and professional athletes. Although there is still not evidence to support it, it is critical to recognize that: the younger the athletes are educated on the ability to identify symptoms and the dangers of under-reporting, the greater the effect on concussion education retention and decision making.

Although the previous argument was rooted in athlete reporting and recognition, it is also crucial that parents, coaches and program administrators are able to identify a concussion. Beyond the identification of a concussion, one of the aforementioned parties needs to take responsibility for facilitating an appropriate removal from play and advanced care plan. Although there is state legislation on concussion education, removal from play, and return to play in every state in the U.S., there is minimal information or designation of who is responsible for the health of the child in a setting without a licensed healthcare professional.[12,28] By evaluating the concussion knowledge of the parents at Glacier Ice Rink, there can be a focus on developing a concussion education program that invokes a sense of parental responsibility while their athletes continue to participate in a setting without a healthcare professional.

After discussing medical care responsibility on a basic level, the question has to be asked, what needs can be assisted from a legislative standpoint. For change to occur, a need has to be identified. Legal action follows cause and the Montana state legislature needs to see research in order to recognize need. There is a misnomer out there that social media and media coverage is enough to create a positive change in the way concussions are dealt

with. While there are many tragic situations to ponder, many positive research findings to appreciate, and many healthcare professionals providing assistance, none of these things has facilitated the creation of a policy or protocol that every child and parent has to abide by. By providing quantitative data representing the current level of preparedness and education, there may be a corresponding legislative recognition of need.

Definition of Terms

1. Concussion: A type of traumatic brain injury caused by a bump, blow, or jolt to the head or hit to the body that causes the head and brain to move rapidly back and forth. [29]
2. Traumatic brain injury (TBI): An insult to the brain from an external force, with the possibility of leading to permanent or temporary impairment of cognitive, physical, and psychosocial functions, with an associated diminished or altered state of consciousness. [30]
3. Mild Traumatic brain injury (mTBI): An individual with a traumatically induced physiological disruption of brain function. Mild Traumatic Brain Injury will present by at least one of the following: any period of loss of consciousness, any anterograde or retrograde amnesia, any alteration in mental state at the time of the accident (e.g. feeling dazed, disoriented, or confused), and focal neurological deficit(s) that may or may not be fleeting. [31]
4. Licensed Healthcare Professional: A registered, licensed, certified, or otherwise statutorily recognized health care professional. In relation to concussion, a licensed healthcare professional is also someone whose training includes the evaluation and management of concussions.[16]

5. Center for Disease Control and Prevention (CDC): The U.S. agency responsible for following and investigating public health trends.[32]
6. Standardized Concussion Assessment Tool (SCAT): Is a standardized tool used to evaluate injured athletes, 13 years and older, for a concussion.[33]
7. Vestibular Ocular Motor Screen (VOMS): The VOMS test is used to assess five areas of the vestibular ocular system. The test includes assessments of smooth pursuits (eyes following a moving object), saccades (rapid eye movement), horizontal vestibular ocular reflex (that stabilizes images during head movement), visual motion sensitivity (related to dizziness), and near-point-of-convergence distance (where eyes can hold together without double vision).[34]
8. King Devick (KD): The King Devick test uses test cards with varying lines of numbers to assess reading performance as indicators of neurological function pre and post-concussion.[35]
9. Standardized assessment of concussion (SAC): Is used to evaluate neurocognitive and neurologic status following a concussion. The SAC is now included within the SCAT.[33]
10. Missoula Area Youth Hockey Association (MAYHA): One of the largest youth hockey programs in the state of Montana, housed at Glacier Ice Rink in Missoula, MT.[36]
11. Dylan Steigers Protection of Youth Athletes Act (DSPYAA): The Dylan Steigers Protection of Youth Athletes Act is Montana's concussion legislation. It promotes safety for youth athletes, requiring each school district to adopt a policy addressing the dangers of concussions. It provides the initial, minimum requirements for the content of each school district's policy.[16]

12. House Joint Resolution 26 (HJ26): The senate and the house of representatives of the state of Montana formally requested an interim study of the implementation of the Dylan Steigers Protection of Youth Athletes Act. The results of the study were to be reported to the 65th legislature.[17]
13. Return to Play (RTP): Following a concussion, an athlete should only return to sport under the supervision of and with clearance from a licensed healthcare provider. There is a five-step return to play progression followed by licensed healthcare providers to safely return athletes to sport.[37]
14. Return to Learn (RTL): Once a health care professional has given permission for the student to return to the classroom, school professionals assist with the student's recovery by monitoring their performance and helping to make decisions on modifications to their school day. Return to Learn is a collaborative team approach between the athlete, the parents, the licensed healthcare professionals, and involved school personnel.[38]
15. Chronic Traumatic Encephalopathy (CTE): Chronic Traumatic Encephalopathy is a progressive degeneration disease of the brain. Individuals at risk are those with a history of repetitive brain trauma. CTE can result following symptomatic concussions and/or a history of asymptomatic sub-concussive hits to the head.[39]
16. Second Impact Syndrome (SIS): A second impact causing injury to the brain while the individual is still experiencing signs and symptoms of a previous concussion. Second Impact Syndrome results in rapid and usually fatal brain swelling.[40]

17. Athlete Exposure (AE): An athlete exposure expresses one unit of athlete susceptibility to injury. It is usually defined as one athlete participating in one game or practice, in which an athletic injury may occur.[41]
18. Post Concussive Syndrome: Post-concussion syndrome occurs when various symptoms-such as headaches and dizziness- last for longer than the recognized 7-10 days of recovery. Post concussive syndrome may occur for weeks, months, or years after the injury that caused the concussion.[40]
19. Sub-concussive contacts: Sub-concussive contact has been defined as a hit to the body or head resulting in movement of the head that causes injury to the brain below the threshold of a concussion. The impact of cumulative sub-concussive contacts is unknown.[42]
20. Theory of Planned Behavior: TPB characterizes an individual's behavior based on their behavioral intention, subjective norms, and attitudes.[11]
21. Body Checking: A defensive player utilizes shoulder to shoulder contact in order to separate the puck carrier from the puck.[43]
22. Athletic Identity: The degree to which an individual views their athletic role as part of their self-concept.[44]

Delimitations

When analyzing the scope of interest for this study, some inclusion factors based on the research design involve recruiting participants that are currently athletes in MAYHA. Youth hockey participants available to participate in the study may also include members of the junior hockey program, under the age of 18, as well as high school hockey players under the age of 18. Youth participants must be at a 5th grade reading level due to the content and

structure of the survey, creating a minimum age requirement of 9-10 years old. Athletes also must be participating in a hockey program in Missoula. The primary delimitation in regards to the participating guardian includes having a child who currently plays hockey in the Missoula youth program. Both guardians of one player were able to complete the questionnaire. A table was set up to accommodate all willing participants with survey materials. There will be no restrictions on who may participate except for age, youth participation in local sport, and guardian status.

Limitations

There are limitations to consider when conducting this study. A low response rate represents one of the greatest limitations of this study. Based on the flow of parents and athletes in and out of Glacier Ice Rink, participants may be missed. Respondents may also represent those most interested in the study and the topic of concussion.

The necessity of a consent form for parent participants, a parent consent form for athlete participants, and an assent form for athletes creates an access issue. There is the issue of carpooling for younger athletes and the issue of high school athletes that drive themselves. These modes of transportation make it difficult to acquire parent consent for athlete participation. Late practice times and "dinner time" practice times may make it hard to get parents and athletes leaving practice to stop and complete the survey.

Surveys were available to athletes and parents before and after practice. The hockey teams get ready for practice together so if there is a strong aspect of athletic identity and a sport culture with a bias toward under-reporting, this may dissuade athletes from participation.[9] Sport culture and bias among parents is another factor that may contribute to limited participation as well.[45]

Threats to Internal Validity

Threats to internal validity to consider include researchers providing additional help on survey understanding and survey content. Guardians may also provide the same kind of advantage to their youth participants if they assist them in completing the survey beyond their available content comprehension. If other sources of information are used to help complete the survey, such as other individuals in the rink or the use of cellular devices, apparent knowledge of signs and symptoms and future consequences could be skewed.

Researcher error in calculation, as well as data entry error, are threats to internal validity. Data from the surveys were hand-entered into an Excel spreadsheet and then analyzed. Any error with data input or spreadsheet organization would lead to a threat to internal validity.

Threats to External Validity

Threats to external validity are compounded due to the nature of the study and the associated effects of the environment, including the individual teams, the rink, the city, and the state of Montana. When generalizing the results to other situations and other people, many aspects must be considered. The sample size of athletes at Glacier Ice Rink is different in size, both smaller and larger, in comparison to other rinks. This research design sampled a youth hockey program without a concussion policy or protocol, unlike other programs. At the state level, the policies, protocols and state legislation all differ in content and requirements[3]. The governing body of the program, for MAYHA it is USA Hockey, may require different levels of training in concussion management. Lastly, comparison of this data amongst other sports must be done carefully due to the influences of popular culture and increased focus on concussion prevention within specific sports.

Chapter Summary

Chapter one has highlighted some of the potential findings of the study, as well as potential impacts these findings may have on concussion education within a local organization. Concussion in sport is an epidemic that is frequently disregarded by many. By evaluating the current concussion knowledge of local athletes and parents, an education program can be developed to tailor to the needs of the group. To further highlight the purpose of this study, current literature on the concussion evaluation process, concussion recognition, youth predisposition, concussion rates within hockey, current concussion education and RTP protocols within hockey organizations, future risks and outcomes of poorly managed concussions, and common education levels will be discussed.

Chapter 2- Review of the Literature

Prevalence and Incidence Rate:

Recent research has done a tremendous job of investigating and trying to quantify the number of concussions experienced by many different ages groups, in many different settings, by many different mechanisms. Due to the nature of the injury and the method of diagnosis, exact numbers are hard to come across. The Center for Disease Control provides the most exact numbers based on emergency room visits, hospitalizations and deaths, with these figures only as recent as 2010. Looking at 2010 as a snapshot, it was found that 2.5 million emergency department visits, hospitalizations, or deaths were associated with traumatic brain injury (TBI) in the United States.[46] When considering the incidence rate for children in the U.S., categorized as 19 years old or younger, the CDC estimated 248,418 children were treated for sports and recreation related injuries including the diagnosis of concussion or TBI in 2009.[46] It was also found that the emergency department visits for sports related concussion or TBI among children rose 57% from 2001-2009, mirroring the 70% in the overall population from 2001-2010.[46] The increase in reported concussions cannot be linked to one direct cause. There is no evidence to suggest that the rise in numbers is because of a dramatic increase in concussion, nor can it be attributed to an increase in education and awareness leading to better reporting patterns by children and parents. However, despite the cause, there is a reported increase in concussion and TBI in the United States.

In the 2015-2016 season, the number of youth athletes participating within the nationwide organization USA Hockey was at 12,184 for the Northern plains district (MT, ND, SD, WY) with Montana contributing 2,057 youth athletes.[47] Montana is experiencing an

immense increase in both youth and adult athletes registered to play hockey. In the category of 19 years and older, Montana is 2,000 athletes larger than the next closest state in the district.[47] The hockey culture that the Midwest is famous for is beginning to thrive within Montana. With an increasing number of youth hockey athletes in Montana, it is important to look at the incidence rate of concussion for this population. Kontos et al.[48] followed 397 youth hockey players over two seasons, evaluating athlete exposures (AE) and number of medically diagnosed concussions. They found an incidence rate of 1.58 concussions per 1000 AEs with the incidence rate ratio 2.86 times higher during games than practices.[48] This is comparable to other sports frequently focused on, such as youth football. Kontos et al.[48] found that younger hockey players, 12-14 years old, experienced a higher rate of concussions than the 15-18 age group. They found that this difference could be due to many factors including an increased risk of concussion from childhood to early adolescence, a disparity between strength, size and speed, and the introduction of checking at age 13.[48] It is also important to note that Echlin et al.[41] reported an AE of 21.52 concussions per 1000 among junior hockey players. This value presents as extreme compared to the 3.1 concussions per 1000 AE in National Collegiate Athletic Association Division 1 hockey and the 1.04 concussions per 1000 AE in the National Hockey League.[41] Junior hockey leagues, all with an age cap of 21, include youth athletes as young as 15 years old. Concussion continues to be an issue across the ages within many varieties of sports and recreation.

Predisposition and Risk Factors for Youth Concussion

There are many pre-disposing factors for concussion that apply to all populations. Such factors, relevant for any individual who may get a concussion, include migraine,

depression, mental health disorders, attention-deficit hyperactivity disorder, learning disabilities, sleep disorders, and previous history of concussion.[14] With concussion being the most common injury in youth ice hockey, making up 15% of injuries for 9-16 year olds and 25% of injuries for boys' high school athletes, knowledge of predispositions and risk factors is crucial[49]. Many different injury risk factors have been studied in relation to ice hockey, the most common being age, session type, level of play, player position, and the presence or absence of body checking.[50] Still, many other factors have only been minimally studied although they have produced leading results. Such factors include team participation in fair play programs (a reward system for staying under a certain amount of penalty minutes in a game), aggression and empathy levels during play, weight and height of the athletes, level of hockey experience, and comparative age and gender demographics within divisions.[50] This section highlights some of the research outlining risks factors for youth participation in hockey.

Younger individuals take longer to recover from a concussion than their older counterparts.[14] Management, return to learn, and return to play of a child or adolescent is typically more conservative.[14] Children may require an increased focus on cognitive rest, longer amounts of time for asymptomatic rest and a longer gradual RTP process.[14] These modifications to management as well as the youth athletes' increased risk of concussion may be due to the amount of structural brain development taking place. Children and adolescents experience increased brain volume and connectivity, reflected by increased white matter volume.[51,52] This structural immaturity proves to be a vulnerability in the face of concussion.[51,52] Youth athletes also experience a greater risk of concussion due to immature myelination, thinner frontal and temporal bones, a greater head-to-body ratio,

and weaker neck musculature.[52] Researchers have expressed concern that an injury to the child or adolescent brain results in a greater risk of long-term functional impairments because of the immaturities previously listed as well as altered neuronal plasticity.[53] Within the category of youth, additional risk factors have been identified for different subsets of athletes.

Most youth athletic programs are divided based on age categorizations. This has been a point of concern for many due to the differences in pubertal stage and consequent anthropometric measures among athletes of the same age. Research revealed bantam hockey players (ages 13-14) showed a difference of height as much as 41cm and a difference in weight as much as 48kg.[54] Injury statistics and pubertal timelines correspond with the age divisions within these teams. One study of 807 youth hockey players found that peewee boy hockey athletes (ages 11-12) had the highest incidence ratio of 23.1 concussions per 1000 AE.[55] This increased injury rate carries over to first year Bantam hockey players who were found to have a greater risk of injury than Bantam players in their second year.[56] Not only do youth athletes in the early stages of puberty have an increased risk of injury but they also have longer symptom duration following concussion in comparison to those in the late stage of puberty, (54.5 days vs. 33.4 days).[49] Overall the differences in age, height and weight seem to contribute to injury in youth hockey.

Gender is another classification typically assessed within research. Studies on concussion risk factors identify gender as a source of disparity. The primary aspect of difference between males and females is the way their bodies respond to force. Studies have shown that acceleration-deceleration and rotational forces related to head impact can cause concussion.[53] In response to this finding, it is also shown that neck muscle

contraction before external head loading helps athletes absorb external forces and increase resistance to movement.[57] Males typically elicit a greater contraction of neck musculature and have a larger neck girth, which are two factors that positively contribute to muscle and joint stiffness. This stiffness is what decreases angular acceleration with external contact to the head.[57] Females produce lower stiffness due to decrease head-neck isometric strength and girth which allows greater angular acceleration, resulting in concussion.[57] While there are many physiological aspects that contribute to greater risk of concussion, there are many aspects of the game that contribute as well.

Hockey includes five players and a goalie on the ice for each team. The five players include three forwards and two defensemen. Player position has a history of predicting concussive injury. Multiple studies have produced similar results showing that forwards followed by defensemen, and then goalies, experience a greater number of concussions.[41,58,59] The percentile range of these studies show that forwards represent 64.1%-71% of the number of concussions recorded among participants, while defensemen represent 29%-32% and goalies, 0%-4.5%.[41,58,59] Time and event prove to influence concussion rates as well, with more concussions occurring in games versus practices and 57% of concussions occurring in the third period.[41,56]

The largest game component contributing to concussion rates among youth hockey athletes is hockey-specific mechanisms of injury, with the leading contributor being checking. Checking has been deemed particularly dangerous in youth hockey due to the previously discussed disparities in size and strength among athletes.[60] Formerly, body checking was allowed within Peewee hockey leagues; however, since 2012, USA Hockey eliminated body checking until Bantams, ages 13-14. Furthermore, the American Academy

of Pediatrics doesn't recommended checking until age 15.[60] Prior to the change in athletes permitted to check, Emery et al[56] found a 3-fold increased risk of concussion among 11-12-year-old ice hockey players who play in a league in which body checking is permitted versus those who play in leagues where it is not. Further support of this age-associated problem with checking, Lax et al[61] found that the majority of concussive events in youth hockey were occurring at age 11. Due to research like this, there was thought that eliminating body checking from Peewee leagues would be an effective injury prevention strategy but checking continues to be dangerous across all age groups.[14] Research involving athletes ages 4-18, showed that although injuries from unintentional collisions were more common than injuries from intentional contact, the injury rates and risk of injury for both were 3 and 4 times higher, respectively, in divisions that allowed body checking.[62] Clearly, checking introduces a more aggressive style of play to the game. Some researchers are going as far as associating this aggressive type of play with altered personality characteristics such as decreased empathy and increased aggression.[63] Emery et al[63] found that youth athletes involved in leagues that check were more likely to respond positively to statements about injuring another player with a body check to increase their team's chances of winning, as well as continuing to check even if they knew it would injure another player. Body checking as a permitted contact in youth hockey presents a large risk factor for injury.

Body checking is not the only body contact that increases risk of concussion in hockey. One study involving youth hockey athletes ages 9-15 found that body contact accounted for 86% of injuries in games, 23% being injuries to the head and neck[15]. Following a check or other unintentional contacts, head impacts can be delivered in many

ways. The most common are shoulder to head contact, extended elbow to head contact and tucked elbow to head contact.[64] One study showed that shoulder to head contact imparted 15% of the attacking player's body mass to the head.[64] Statistics from the NHL support the severity of body to head impacts, reporting that 68% of concussions sustained between 2006 and 2009 were due to body to head contacts.[64] USA Hockey focuses on teaching appropriate body position, and for checking this involves anticipating a collision, readying the body, and driving the legs through the collision[47]. Despite the focus and attention on proper technique, head contacts can't be completely prevented with correct body positioning.

There are many predisposing factors to head injury in youth hockey. Under-development, age, height, weight, gender, position, time of play, body checking and other body contact all prove to be risk factors for concussion for youth athletes. Similar to the large variety of pre-disposing factors, there are many different signs and symptoms that a concussed athlete may present with. Highlighted below are some of the most commonly reported signs and symptoms.

Signs and Symptoms:

A concussion results following rapid acceleration-deceleration and rotational forces to the head.[65] These forces cause deformation of the neurons, glial cells, blood vessels, and alter membrane permeability, contributing to the associated abnormal neurometabolic cascade.[65] A potassium efflux, calcium influx, alteration in the sodium-potassium pumps, and glutamate release all occur post-injury.[53,65] These alterations result in an increased use of adenosine triphosphate by ion pumps to restore the normal cell membrane permeability.[53] The hyper metabolism of glucose, increased use of adenosine triphosphate,

and decreased cerebral blood flow following injury create a cellular energy crisis.[53,65] The effects of this process present in many different ways.

The assessment of a concussion involves looking at many different aspects of the individuals' behavior and response. The reporting of clinical symptoms and physical signs by the affected individual is imperative, although the types of signs and symptoms often associated with concussion are also attributed to normal experiences such as dehydration and fatigue.[14,52] Due to this association of symptoms with other physical experiences, the evaluator must also assess cognitive impairment, neurobehavioral features, and sleep disturbance[14].

The most commonly reported symptom of a concussion is a headache, reported by 65-93% of affected individuals.[53] Following headache, the most frequently reported symptoms are fatigue, dizziness and trouble with mental activity.[53] The CDC reports other symptoms commonly reported by children as nausea or vomiting, balance problems, double or blurry vision, sensitivity to light, sensitivity to noise, feeling sluggish, concentration problems, memory problems, confusion, and not feeling right.[66] All of these concussion symptoms can only be treated correctly if they are appropriately reported.

Concussion Reporting Behavior:

Tireless work is being done to validate and improve concussion evaluation tools.[14,52] Assessments such as the King Devick, Vestibular Ocular Motor Screening, SCAT3, ImPact test, force plate assessments, alternative imaging techniques, and various biomarkers are all being studied in efforts to identify the best evaluation method.[14] None of these assessments are beneficial if the athlete doesn't report a concussion. Rates of reporting and

reasons for under-reporting are important to consider when working with any athlete population.

While 1.6 to 3.8 million children are seen and assessed for sport-related concussion each year, there are numerous children that are never evaluated or treated.[1] It is estimated that somewhere between 20%-60% of athletes with concussion symptoms do not report them.[9] Kurowski et al[67] illuminate the most common reasons for under-reporting as athletes not realizing they suffered a concussion, athletes thinking their injury is not serious enough to require attention, athletes thinking their injury posed minimal danger, an overall minimal knowledge of concussion, and avoidance of being withheld from participation. Alongside deficits in concussion knowledge and insistent desires to continue participation, external pressures for continued participation is the third pillar of under-reporting. Youth athletes aren't acknowledging their concussion symptoms, understanding that they may have a concussion, and then reporting. They are recognizing symptoms and then weighing in many outside factors before deciding on their report decision. One study found that when presented with a scenario involving concussion symptoms in a game situation the majority of high school students said they would keep playing and see how they felt and others said they would take a little break and likely go back in[9]. None said they would completely stop playing when experiencing possible concussion symptoms. The most frequently reported reasons for under-reporting of concussion symptoms are discussed below.

Often times, instituting requires asking what the population needs the most and then what is the most changeable. When it comes to concussion reporting, the current lack of concussion knowledge has been deemed the most changeable. There have been many

links identified between a lack of knowledge of signs and symptoms, future consequences, and importance of reporting and the consequent lack of reporting.[68,69] Trends across many studies of athletes, parents and coaches all show similarities in the thought process and the lack of knowledge that results in under-reporting. Research suggests athletes under-report due to a lack of knowledge, often reporting that their symptoms didn't feel severe or serious enough to warrant medical attention.[69] Sport culture and history also contribute to athlete under-reporting. Athletes report that dated language such as bell-ringer or dings represent part of athletics and are consequentially not reported.[70] Research shows that coaches have a similar belief associated with these old terms.[71] In a study by Faure and Pemberton[71], football coaches were presented with a scenario where an athlete had his bell rung, was presenting as disoriented but returned to the huddle on their own. Forty-two percent of the coaches believed that the player had not sustained a concussion.[71]

Efforts towards changing these two very straightforward, yet very important, beliefs have shown promise. One study found that when concussed athletes were provided the definition of concussion and a description of symptoms they were better able to recognize they had sustained a concussion.[69] On the other hand, improved recognition of concussion doesn't necessarily equate to an increase in reporting. Kroshus et al[25] studied the knowledge and reporting behavior of a group of NCAA collegiate hockey players after receiving concussion education and found there was no overall increase in knowledge or intention to discontinue playing when concussed. For this reason, it has been stressed that parents of youth athletes be educated to recognize signs and symptoms of concussion.[52] The desire to continue participation is a strong component of athlete under-reporting.

The combination of a lack of knowledge and failure to assess situations for risk may contribute to an athlete's action of returning to play while concussed. Without proper education on concussions and assessing risk, the decision to report may appear as a black and white question. Do they wish to continue playing or not? Athletes see themselves as crucial players on their teams. Both the role they play on the team and their own personal desire to continue participation increase rates of under-reporting. McCrea et al[69] found that over 50% of concussions in high school football players go unreported with the motivation to continue participation as one of the main explanations. Other explanations include a lack of perceived seriousness of the injury, hurting the team's performance, not wanting to let teammates down and fear of not being allowed to start playing when they believe they are ready.[4,9,21] All of these concepts are frequently reinforced by external sources.

The Theory of Planned Behavior includes three main components: attitude, subjective norm, and perceived behavioral control.[12] Together these three factors make up 53% of an athlete's intention to report a concussion.[12] Athletes reported that attitude has the greatest influence on their reporting behavior, which is created by both socials norms and personal experience.[12] Subjective norm is identified as another major influence on reporting behavior. While attitudes reflect how the subject feels about the behavior, subjective norms reflect how the subject believes external influences view the behavior. Studies indicate that athletes assess how their teammates, parents, and coaches support concussion reporting before they decide on reporting action or inaction.[9,10,12] In one study, athletes discussed the well-known sport culture where reporting concussion symptoms made the player look weak.[9] This contributes to the "win at all costs" attitude that has trickled down from professional sports. The athlete's perception of parental and coach

attitude towards concussion reporting supports the win, or play, at all costs attitude. Research suggests that student athletes assess how their parents feel about reporting before deciding whether or not to report.[12] They also assess which coach they are playing for and the acceptability of the cessation of play.[9] External influence is viewed as a significant predictor of behavior, alongside concussion knowledge and personal attitude. When an athlete chooses not to report there are many future consequences that may result.

Future Consequences:

Concussion has ties to a multitude of different neurological outcomes. While the exact relationships are not perfectly defined and causal relationships cannot be made, there is convincing research connecting mTBI to many tragic future outcomes. Second impact syndrome and chronic traumatic encephalopathy are the most well-known due to the tragic results. Second impact syndrome occurs following a previous, unresolved concussion. After an additional contact within the symptomatic time frame of the first concussion, within the first several weeks, the individual experiences cerebral edema and herniation due to auto-regulatory dysfunction and ion fluxes.[72] Second Impact Syndrome has near a 100% mortality rate. It has occurred in association with football, boxing, karate, and ice hockey and occurs more often in patients with immature brains.[52,65]

Chronic Traumatic Encephalopathy (CTE) is a neurodegenerative disorder characterized by hyper phosphorylated tau deposition in the brain.[73] CTE is only found post-mortem and is associated with behavioral changes, executive dysfunction, memory deficits, and cognitive impairments.[65] CTE was first discovered in an autopsy of a NHL player in 2009.[41] Since then, the discovery of CTE in the autopsies of three prominent NHL fighters has attracted the attention of the hockey community.[74] Research does not delineate

which populations are at greater risk or what exactly causes CTE in one individual and not another. For now, providers care for athletes by appropriately handling any reported concussions. For complicated patients with protracted symptoms or extensive histories they consider the outlined risk factors for disqualification from sport. These include: a severe and prolonged recovery, longer recovery times with successive concussions, progressively lower impact necessary to cause a concussion, functional impairment in school or work, neurocognitive dysfunction on exam, abnormalities within a neurological exam associated with head injury, or structural brain injury identified via imaging.[75,76] There are additional long-term consequences to consider when individuals and medical providers are discussing disqualification from sport.

The literature suggests ties between a single moderate or severe TBI and accelerated neurodegeneration, including Alzheimer's disease, Parkinson's disease, and motor neuron disease.[65] The associated increased risk and earlier onset for Alzheimer's disease has also been shown among retired professional football players[41]. Retired professional football players, a population vastly studied, with a history of 3 or more concussions were 3 times more likely to be diagnosed with depression, 5 times more likely to report cognitive impairment, and 3 times more likely to report memory impairment.[77] Although professional athletes are studied copiously they are not the only ones suffering from the extensive effects of concussion on an imminent basis.

Children, adolescents, high school athletes, and collegiate athletes have been represented in numerous studies focused on post-concussion syndrome (PCS).[78] The timeline for what is labeled post-concussion syndrome varies. Some consider it any symptoms outside of the initial 10-day window and others not until 3 months post-

concussion.[14,78] Regardless of the time frame chosen, PCS is typically linked to four domains of prolonged issues including sleep, emotional, cognitive and somatic. PCS is present in 1.5% to 15% of youth athletes, higher within elite ice hockey populations, and has lasting effects on exercise tolerance, neurocognitive function, working memory, and reaction time.[14,78] Many studies highlight the prevalence of PCS in youth.[14,79,80] Research shows that at three months following concussion, 15% of athletes, ages 11-22, reported at least one symptom.[80] Even more alarming is the research that shows following apparent clinical symptom resolution, individuals continue to experience neurological deficits.[14,81] Recent research goes as far as exploring the association between concussion and lower extremity injuries in collegiate athletes.[82] All the effects, both immediate and future, of concussion are not known; but the research available urges providers to take an increased level of caution, especially when caring for youth.

Education as an Initiative:

Concussion knowledge has been assessed to establish foundational knowledge for all parties involved in patient care. While some states have the resources to have a healthcare professional available at every athletic event, others do not. Often the parents, coaches, and administrators are left trying to navigate the early stages of care for a concussed athlete. The information these different entities retain about concussions, as well as what information the athlete needs in order to support the reporting process, has direct effect on the treatment of the athlete.

Athlete concussion education is a tricky venture. Research shows that only some of the most engaging methods of delivering information had lasting effects on knowledge retention.[83,84] Athlete testimonials, videos, and video games generated the greatest scores

for recalling signs and symptoms.[25,83,84] Research shows that with traditional methods, education scores increase immediately post-education and decrease with time.[67] The demographics of the athlete also plays a part in the length of retention and the corresponding reporting behavior. Although there is initial retention of concussion education in most studies, overall attitude and behavior of the athlete remains unaffected. Kurowski et al[67] reported 75% of athletes educated on concussion continued to play despite recognizing concussion symptoms. Eagles et al[84] found that although concussion knowledge levels increased in their Bantam and Midget athletes after receiving concussion education from a retired hockey player, the concussion attitude scores did not maintain a change with follow up. Attitude towards concussion plays a large part in athlete reporting behaviors, but confidence is maintained that annual education has an effect on an athlete's perspective. Currently, the 13 to 15-year-old age range is the most receptive to information about concussions[21]. This may be a good place to start.

Concussion education is important for all groups involved in patient care, especially if athletes are reporting they are choosing to continue playing despite recognition of symptoms. Parents and their concussion education level are a very important contributor to athlete perspective.[45] Misconceptions and inaccurate information about concussion are still a problem in the parent population. Mannings et al[5] found that only 65.3% of parents studied were able to identify a concussion as a mild traumatic brain injury and only 42.2% reported that a concussion occurs by something other than a blow to the head. Mannings et al[5] also found that only 13.2% of their sample was able to correctly identify all statements about concussion. An even larger representation of a lack of parental knowledge is that 80% of adults polled still believe that people should not sleep after a concussion and they

should be woken up periodically.[85] This demonstrates that concussion education is not being distributed to parents in a way that keeps them updated on current findings. Many parents have taken it upon themselves to find current information, with a large number of parents turning to the internet for concussion information.[5]

The individuals more commonly informed have also been studied. Females are better at identifying signs and symptoms of a concussion, as well as teasing out distractor symptoms.[86] Females were also more likely to identify a concussion as a critical issue.[21] On the contrary, males have been shown to be more aware of concussion return to play guidelines.[87] Despite previous research, an opposing study indicates sex does not play a role in concussion knowledge but does play a role in concussion attitude.[20] Alongside the many differences in concussion knowledge and attitude based on gender, age is another variable to consider. Parents in the age range of 46-50 years old, as well as parents of athletes ages 10-13 years old, were significantly more likely to report hearing about concussions in comparison to their age-related counterparts.[21] Although, what appears to be the most significant age-related finding is that only 20% of parents ages 18-25 years old reported hearing about concussions.[21] Other factors such as ethnicity, household income, and a parent history of unreported concussion also had significant effects on concussion knowledge.[20]

The concussion knowledge of the coach is another important factor in athlete care. Typically, the coach has the first opportunity to take action in removing an athlete from play. Many organizations mandate concussion education for their coaches prior to the start of the season. Increased knowledge about concussion, in relation to a greater number of years coaching, has been a positive predictor of symptom recognition.[88] Most coaches

report they would remove their athletes from play in different situations, but reporting decreased when factors such as type of game (championship, final game) or severity of the concussion (minor, severe) were added to the scenario.[6] Despite the positive results from educational efforts with symptom recognition by experienced coaches, other research shows that only 1 in 5 coaches rate themselves as having a high concussion knowledge base.[89] Similar to the parents, coaches are getting most of their information from news sources versus licensed healthcare professionals and are also following the trend of believing popular misconceptions.[89] Nationwide, states have produced individual legislative efforts in order to organize and manage the flow of information about concussions.

Legislation takes over:

Concussion legislation took five years to spread nationwide, but as of February 2014 all 50 states and the District of Columbia passed concussion legislation to help protect youth athletes.[53] The short amount of time it took for each state to pass lergislation is impressive based on the fact that concussion legislation is the only legislation that mandates medical attention following an injury.[90] The first law in relation to youth concussion was passed in the State of Washington in May 2009 after a middle school football player, Zackery Lystedt, returned to play following a big hit and experienced catastrophic brain injury.[91] Lystedt underwent two major brain surgeries, was in a coma for a month, and was on a feeding tube for 20 months.[91] Today, after significant progress, Lystedt is the face for concussion education and youth concussion legislation. The Zackery Lystedt Law states that a youth athlete playing or practicing on public property must be removed from play if there is a suspected concussion. The youth athlete must be evaluated

and cleared by a licensed health care provider before returning to play.[92] It is not known if laws similar to the state of Washington's have had significant effect on concussion reporting and proper care of athletes following a concussion but there is hope that the legislation will help. The problem proves to be the variety among the laws when compared state by state. There are many states still missing important components.

Concussion legislation has been effective with assisting in concussion recognition since the initial law passed in 2009.[90] Research shows a jump of treated concussions from 4.98 per 1000 children in 2006 to 13.27 per 1000 children in 2012.[90] Other increases have also been noted, including a 10% increase of health care utilization by 2012 in states with concussion legislation compared to those without, a 150% increase of pediatric concussion referrals to neurologists by 2012, and a 92% increase in health care utilization by children ages 12-18 in states with concussion legislation by 2012.[90] These increases can all be due to state legislation, as well as improved access to health care providers. Although the legislation varies, overall positive results are reported. This success precedes the question and contemplation of an easier, more uniform policy for all states.

The Korey Stringer Institute has nine recommendations for state concussion legislation: 1) schools should develop an emergency action plan and referral plan for concussions; 2) use certified helmets and equipment; 3) A pre-participation exam including concussion specific questions; 4) Preseason concussion education for coaches and athletes; 5) Athletes with a suspected concussion should be removed from play and not allowed to RTP the same day; 6) Athletes with a suspected concussion should only be allowed to RTP following clearance from a licensed healthcare professional; 7) No athlete should RTP if they have been unable to return to school; 8) Implementation of a gradual RTP protocol; 9)

Medical management plan for an acute head or cervical spine injury.[93] Most state concussion legislation includes only three main components: 1) education for parents, coaches, and athletes; 2) the removal from play of an athlete with a suspected concussion; 3) and clearance from a licensed healthcare professional prior to the athlete returning to play.[90] Variation between laws is noted in regards to the licensed healthcare professional qualified to clear athletes to return to play, the youth athletes included in the legislation, the types of concussion education required for coaches, parents, and athletes, and the responsibilities of the parent. While some laws require a licensed healthcare professional trained in concussion management to clear an athlete to return to play, other laws are less specific, allowing healthcare professionals untrained in concussion to return athletes to play.[94] Variation in the types of youth athletics included in the state legislation (ex: school sponsored, non sponsored) is also noted from state to state. Only 13 states extend the legislative requirements to private entities, or youth athletics not associated with a public school. Most recently, Delaware amended their original state concussion legislation, enacted in 2011, to include private schools, travel teams, and youth organizations.[95]

Discrepancy is also noted in the education requirements of coaches and parents. Half of the state laws require coaches to undergo a formal concussion management program and 26 states require parents undergo formal concussion education.[3,28,94] Most state laws simply require that parents and coaches receive concussion education materials. Similar figures represent the number of coaches and parents that must receive concussion education material, 80% and 43 states, respectively.[3,28,94] Discrepancy between state laws is easily seen when evaluating parental responsibility. Analysis of state laws nationwide showed that only 2 states required parents to remove their child from play if they

suspected a concussion and only 5 states required parents to report a suspected concussion to their child's school.[28] These types of legal discrepancies are making it difficult to evaluate compliance, as well as creating confusion among parents and coaches as to their role in the concussion reporting process.

Montana's concussion legislation was enacted in 2013 and was the 47th concussion law to pass in the United States.[28] It contains similar components to other state legislation, requiring each school district in Montana to adopt a policy to inform involved parties of the nature and risks of a concussion, signs and symptoms of a concussion, and the necessity of medical attention for the affected athlete.[16] The Dylan Steigers Protection of Youth Athletes Act, Montana's state concussion legislation, requires the removal from play of a concussed athlete and clearance by a licensed healthcare professional prior to their return to play.[16] While the DSPYAA accurately defines a licensed healthcare professional as an individual also trained in the evaluation and management of concussion, it defines youth as only those participating in school-sponsored activities.[16] Following a formal evaluation of the law, where it was found that overall athletes and parents scored less than 60% on a survey assessing identification of concussion signs and symptoms and future consequences, the Dylan Steigers Protection of Youth Athletes Act was voted to remain in its original form.

Concussion management in hockey

Concussion recognition at the state level may have come a long way since 2009 but the battle of concussion recognition by sport associations is an ongoing struggle. Although the National Hockey League has had a professional concussion committee since 1997, updates to their policy weren't made until 2010 and they were made without a neurologist on the panel.[95,96] The NHL's current policy includes baseline neurocognitive testing and a

gradual return to play protocol requiring the athlete to be symptom free after each phase and back to baseline on cognitive assessments.[95] The NHL also utilizes a neuropsychologist before every athlete's return to play.[95] The most recent change to the NHL's policy is the addition of two concussion spotters at every game, whose primary job is documenting any possible hits or occurrences on the ice that may cause a concussion.[97] The American Hockey League is following in the NHL's footsteps. Although they do not track concussions they have made efforts to reduce the amount of fighting that occurs in the league.[74] If an athlete engages in two fights during a game, then they are ejected. The new 2014-2015 rule change has decreased the number of major penalties for fighting in the AHL.[74] While both leagues indicate they are changing as research presents new information, a class action lawsuit against the NHL says otherwise.

Currently, there is a class action lawsuit against the NHL with 105 NHL players supporting the suit. They claim that the NHL failed to protect them from the long term effects of head trauma.[74] The class action suit has been ongoing since November 2013, with the latest development occurring in May 2016 after a district judge denied the NHL's motion to dismiss the plaintiff's amended complaint.[98] As of October 2016, the NHL continues to deny a connection between head injuries and future complications like Chronic Traumatic Encephalopathy.[99]

On a level a little closer to home, USA Hockey has failed to publish concussion education requirements for their coaches, athletes and associated youth hockey organizations. All of the athletes participating in Missoula Area Youth Hockey must be registered with USA Hockey, as well as their coaches. Prior to and while collecting data at Glacier Ice Rink, there were no concussion education requirements mandated by the

Missoula Area Youth Hockey Association and no published requirements by USA Hockey. The purpose of this study is to assess the current level of concussion education at Glacier Ice Rink with the intention of developing a concussion policy and education method fitting to the youth hockey players and their parents in the Missoula Area Youth Hockey Association.

Chapter 3

Many studies have chosen to use surveys across different sports and age categories to assess concussion knowledge and attitude.[5,10,21,23,24,25] Due to a lack of concussion education being identified as a barrier to reporting, as well as a barrier to appropriate care, education mandates have become one of the main foci of mTBI legislation.[3,28] Montana passed its own concussion legislation in 2013.[28] Following the outline of previous states, Montana's law mandates certain elements be part of the district or school policy.[16] The biggest issue within Missoula, and statewide, is that this legislation does not include non-sponsored athletics. Any sport not associated with a school is considered a non-sponsored activity in the state of Montana. This research focused on measuring the concussion knowledge of parents and athletes in one specific, non-sponsored sport.

Participant Population

The organization USA Hockey had 542,583 players for the 2015-2016 hockey season, with 4,583 of those players participating in Montana and 907 of those players being between ages 11-18.[47] Participants for this study included both parents and athletes from the MAYHA, that is housed within Glacier Ice Rink. Participants included youth hockey players, ages 10 to 18 years old, and guardians of players ages 3 to 18 years old. The athletes being surveyed were within their winter season, keeping in mind that there are also Fall and Spring programs. The sample included three different types of teams: in-house, in-house select, and travel. Within those teams age divisions include: termites (6 and under), mites (8 and under), squirts (10 and under), peewee (12 and under), bantam (13 and 14), girls U14 (14 and under), and men's and women's varsity hockey (Missoula Bruins). All of these teams, with the addition of A and B teams for some categories, combine

for a sample of around 340 athletes. This study used an estimate of 44% of the sample being 5th grade or older, for a target sample of 150 athletes.[47] This study also assumed that each participant has two guardians for a parent sample of 680, this includes parents for all age categories of youth hockey participants.

Selection Eligibility Characteristics

Athlete participants in this study must be currently participating on a MAYHA team, which is considered a non-school sponsored activity. Participants must be under the age of 18 and over the age of 10. The minimum age requirement is due to the survey being written at a 5th grade reading level. Participants must have had a guardian available to sign a parent informed consent form and the participants must sign an assent form. Any adult considered the legal guardian of a current MAYHA or high school hockey athlete could participate in the study. Adult participants signed an informed consent form.

Research Sample

A total of 53 athlete participants and 204 adult participants was the sampling goal for this study, which represents 30% of the target sample.[100] Convenience sampling was done throughout time periods where all aforementioned teams were at the rink at least once during sampling. The sampling characteristics remain the same as the selection-eligibility characteristics, with a greater push for participants who have a guardian available to provide a consent form. In efforts to recruit more participants than those interested in the topic, incentives were advertised. Hockey skates, ranging from $65 (youth) to $800 (high end adult) are considered a desirable incentive and served as our main incentive for players. The primary incentive for parents was a Kindle Fire. Other incentives (hockey water bottles, pucks, socks, t-shirts) were given out as well. The survey

table was positioned by the main entrance, although participants can enter and exit the rink through many different entrances.

Study Instrument:

Developers, Purpose and Content of Instrument:

The parent and athlete surveys were developed and modified from existing surveys in an effort to capture the current concussion knowledge of Missoula parents and athletes within Missoula Youth Soccer, Missoula Youth Football, and Missoula Youth Hockey. [101,102] Demographic information involves years played in the sport, gender and age. The survey contains questions regarding symptom identification, consequence identification, if they had discussed the consequences of concussion and if they had formal education about concussion. Survey questions and content is based on previous studies assessing concussion knowledge and includes some, but not all, signs and symptoms of a concussion and future consequences of a concussion.[19,33,101,102] Distractors were chosen based on previous studies as well, and only represent a small portion of possible distractors.[101,102] Additional survey questions assess the athlete and parents' view on their understanding of dangers of concussion, knowing the signs and symptoms, and two RTP scenarios. Lastly, they were asked about the form of education they would like to receive in the future.

Format of items:

Both surveys are organized with demographic information at the beginning of the survey, followed by determination of signs and symptoms. Signs and symptoms, as well as future consequences, are structured in a belief format.[103] Belief questions assess what the participants believes is true or false and can be used to calculate knowledge related to the topic.[103] The survey was written in a closed-ended format with responses presented in

random order within each category.[103] There are two sections of 10 signs and symptoms, including distractors, followed by two sections of 12 future consequences, including distractors. Next there are two yes/no questions about formal education and parent/athlete communication about concussion. The following four questions use a Likert scale to assess attitude and viewpoints of the participants.[103] Five categories are used on the Likert scale including: disagree completely, somewhat disagree, neither agree or disagree, somewhat agree, agree completely.[103] The final question is a multiple choice question regarding preferred education method.

Administration, Scoring, Interpretation, and Administrators:

The survey was administered by myself, an ATEP research assistant, and faculty advisor throughout the week of February 1st, 2016. Surveys were distributed Monday through Thursday from 4pm to 7pm at Glacier Ice Rink. This time frame allowed all divisions of the sample the opportunity to be a part of the study. Participants either received a parent survey and informed consent form attached to a clipboard or an athlete survey, assent form and informed consent form for the guardian to sign. Participants were guided through the consent form and asked to complete the two-sided survey by the research table. Following completion of the survey the participant filled out a ticket to be entered in a drawing for an incentive prize.

Survey content was not be explained or described to any participants unless definition of a term is necessary or clarification of question content. Youth participants are able to have a researcher read them the question, or a specific word, if they need assistance. Questions/words are to be read exactly as they are written on the survey. Participants were asked to avoid discussion with other parents or youth participants while taking the

survey, as well as, avoidance of using mobile references. The estimated time to complete the survey is 5-10 minutes.

Score Reliability:

Score reliability indicates that consecutive scores on the same test will be similar with each try[102]. It is known that score reliability is necessary to have a valid test, but reliability does not always indicate that the instrument is valid.[103,104] Score reliability is assessed in different ways: test-retest, equivalent forms, internal consistency, and inter-scorer.[105] For this study, internal consistency will be used to assess score reliability. A measure of internal consistency is known as coefficient alpha, or Cronbach's alpha, and it will be used to demonstrate the relationship between variables.[104,106] A large Cronbach's alpha is considered equal or greater to 0.70.[106] Cronbach alpha scores from previous studies using this instrument report a Cronbach alpha of athlete scores 0.72, parent scores 0.81, and combined scores 0.83 on symptom identification.[7] In addition, the identification of future consequences yielded a Cronbach alpha of athlete scores 0.62, parent scores 0.70, and combined scores 0.71.[7]

Validation Procedures for any new instrument:

Validation of any new instrument in research is necessary. Without validation, the research cannot be considered an accurate representation or assessment of the involved variables.[103] To ensure that what is being measured is what the research intended to measure, and that the interpretations made based on the outcome of the research are correct, there are four main types of validity that must be established. These include face validity, content validity, construct validity, and criterion-related validity. [103,104]

Face validity of both surveys intended for use in this study was established by a panel of 5 certified athletic trainers. The survey was evaluated to determine if the surveys measure what they are intended to measure. The involved athletic trainers assessed the surveys for inclusion of appropriate signs, symptoms, and future consequences, as well as appropriate distractors.

Content validity is essential in ensuring that the survey assesses all essential aspects of concussion knowledge. The primary focus of the survey is to determine if the athlete and parent are able to identify the signs and symptoms of a concussion. Components such as the definition of concussion, metabolic cascade associated with the injury, and treatment options are not assessed because the primary focus is to determine if the individual is able to accurately identify a possible concussion. The second section of the survey focuses on the actions of the individual after identifying that they, or their child, may have a concussion. It is important to determine if the participants understand future consequence of failing to report or of a poorly managed concussion. Content validity was established via the panel of certified athletic trainers. Content and face validity were also established based on surveys previously developed to assess the same components of participant knowledge. This principle is called the development of concurrent validity, which is done by correlating a new assessment with an established assessment. [101,102]

Quantitative Procedure

Ethical Nature of Data Collection:

The study was approved by the University of Montana's Institutional Review Board for the Protection of Human Subjects in Research on August 7th, 2015. All researchers completed the human subjects' protection training prior to approval. Adult research

participants were informed of all study information via an informed consent prior to the completion of their survey. Athlete participants were given an informed assent with study information, as well as a parent consent form, to participate in the study.

Research Paradigm/Design:

This study was conducted using a quantitative research paradigm. The over-arching name for quantitative data can be deemed positivism.[104] Positivists generally believe that there is one reality and that it can be measured. This leads to the idea of quantitative data providing significant correlations and the prospect of investigating causal relationships.[104] This research was evaluated by a quantitative paradigm based on the scoring of the survey and the lack of open ended questions for coding purposes.[103]

This study utilized a cross-sectional survey design. A cross-sectional design is typically used in descriptive studies, with an aim to determine the prevalence of a specific outcome for a population, or subgroup, at a given time point.[107] A convenience sample, participants that are easy to reach, comprised the sample. Cross-sectional designs are also typically used in public health planning to develop further hypotheses related to disease.[107] This is one of the main objectives of the assessment of concussion knowledge at Glacier Ice Rink. A quantitative picture of concussion knowledge of the survey participants will aide in developing future education programs for this program.

Quantitative Analysis

Method of Analysis (including significance level):

Data from each questionnaire was entered into Excel (version 2010; Microsoft Corporation, Redmond, WA). Descriptive statistics were used to determine the frequency of identification of each symptom and the consequence of concussion, as well as the

percentage of participants who have received education from a formal source. The surveys were scored by calculating a composite score for each participant. This was done by coding the correct and incorrect answers for the symptom and consequence questions. Composite scores were generated by adding the total possible correct signs/symptoms and consequences and awarding 1 point for each correctly identified minus 1 point for each distractor selected. The final score calculated is the composite score. The total possible points on the survey is 22. An evaluation of the association between the education received and the composite score was done with linear regression using SPSS (Version 21.0; IBM Corporation, Armonk, NY). Cronbach's alpha was used to assess internal consistency on the symptoms and consequences scale.

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Concussion Knowledge in Youth Sports Participants and Their Parents in Western Montana

Athlete Survey

What sport do you currently play? (Circle one) Football Hockey Soccer

Age: _____ Gender (Circle): Male Female

How many years have you played this sport? ____

Section 1 Symptoms

1. Which of the following are <u>symptoms</u> of a concussion after sustaining a hit to the head? **Please circle all that apply.**
    a. Vacant stare/glassy eyed
    b. Drowsiness
    c. Difficulty Breathing
    d. Nausea or Vomiting
    e. Irritability (Bad Temper)
    f. Neck Pain
    g. Inappropriate emotions (Out of Place Feelings)
    h. Pale skin
    i. Excess Sleep (sleeping longer than usual)
    j. Sensitivity to light (photophobia)
2. Which of the following are <u>symptoms</u> of a concussion after sustaining a hit to the head? **Please circle all that apply.**
    a. Muscle spasms in your neck
    b. Black eye
    c. Sensitivity to noise
    d. Feeling like "in a fog"
    e. Poor balance/coordination
    f. Epistaxis (bloody nose)
    g. Fatigue (low energy, tired)
    h. Jaw pain
    i. Sadness (Depression)
    j. Ringing in ears (Tinnitus)

Section 2 Outcomes

3. Which of the following do you think are <u>consequences</u> of inappropriate care of a concussion? **Please circle all that apply.**
    a. Early onset dementia
    b. Increased risk of stroke
    c. Persistent dizziness
    d. Persistent neck pain
    e. Death
    f. Persistent headache

4. Which of the following do you think are <u>consequences</u> of inappropriate care of a concussion? **Please circle all that apply.**
    a. Bleeding in the brain
    b. Early onset Alzheimer
    c. Increased risk of blindness
    d. Early onset Parkinson's
    e. Persistent dizziness
    f. Persistent jaw pain

Section 3 Education.

5. Have you ever talked about the consequences of a concussion with your parents or guardians?
    a. Yes
    b. No

6. Have you ever had formal education about concussion? (In school, or online)
    a. Yes
    b. No

7. I understand the dangers of concussions. (**Select one**)

Disagree completely	Somewhat disagree	Neither Agree Or Disagree	Somewhat Agree	Agree Completely
(1)	(2)	(3)	(4)	(5)

8. I know the signs and symptoms of a concussion. (**Select one**)

Disagree completely	Somewhat disagree	Neither Agree Or Disagree	Somewhat Agree	Agree Completely
(1)	(2)	(3)	(4)	(5)

9. If I am hit in the head and have a headache, it is OK to continue to play, as long as I didn't lose consciousness (i.e., black out). (**Select one**)

Disagree completely	Somewhat disagree	Neither Agree Or Disagree	Somewhat Agree	Agree Completely
(1)	(2)	(3)	(4)	(5)

10. If I think I may have a concussion, it is OK to continue to play hockey. (**Select one**)

Disagree completely	Somewhat disagree	Neither Agree Or Disagree	Somewhat Agree	Agree Completely
(1)	(2)	(3)	(4)	(5)

11. Given the choice, in what form would you like to receive educational information about concussions?
    a. Power-point
    b. Poster
    c. Pamphlet
    d. Flyer
    e. Other

Concussion Knowledge in Youth Sports Participants and Their Parents in Western Montana

Parent/Guardian Survey

What sport do is your son/daughter currently playing? (Circle one) Football Hockey Soccer

What is your age? _____ Gender (Circle): Male Female

Section 1 Symptoms

1. Which of the following are <u>symptoms</u> of a concussion after sustaining a hit to the head? **Please circle all that apply.**
    f. Vacant stare/glassy eyed
    g. Drowsiness
    h. Difficulty Breathing
    i. Nausea or Vomiting
    j. Irritability
    k. Neck Pain
    l. Inappropriate emotions (out of character)
    m. Pale skin
    n. Excess Sleep
    o. Sensitivity to light (Photophobia)

2. Which of the following are <u>symptoms</u> of a concussion after sustaining a hit to the head? **Please circle all that apply.**
    p. Muscle spasms in your neck
    q. Black eye
    r. Sensitivity to noise
    s. Feeling like "in a fog"
    t. Poor balance/coordination
    u. Epistaxis (bloody nose)
    v. Fatigue or low energy
    w. Jaw pain
    x. Sadness
    y. Ringing in ears

Section 2 Outcomes

3. Which of the following do you think are <u>consequences</u> of inappropriate care of a concussion? **Please circle all that apply.**
    a. Early onset dementia
    b. Increased risk of stroke
    c. Persistent dizziness
    d. Persistent neck pain
    e. Death
    f. Persistent headache

4. Which of the following do you think are <u>consequences</u> of inappropriate care of a concussion? **Please circle all that apply.**
    a. Bleeding in the brain
    b. Early onset Alzheimer
    c. Increased risk of blindness
    d. Early onset Parkinson's
    e. Persistent sadness
    f. Persistent jaw pain

Section 3 Education

5. Have you ever discussed the risks associated with concussions with your child?
    a. Yes
    b. No
6. Have you ever had formal training about concussions? (Online or in school).
    a. Yes
    b. No
7. I understand the dangers of concussions. (**Select one**)

Disagree completely	Somewhat disagree	Neither Agree Or Disagree	Somewhat Agree	Agree Completely
(1)	(2)	(3)	(4)	(5)

8. I know the signs and symptoms of a concussion. (**Select one**)

Disagree completely	Somewhat disagree	Neither Agree Or Disagree	Somewhat Agree	Agree Completely
(1)	(2)	(3)	(4)	(5)

9. If your child is hit in the head and has a headache, it is OK for them to continue to play, as long as they didn't lose consciousness (i.e., black out). (**Select one**)

Disagree completely	Somewhat disagree	Neither Agree Or Disagree	Somewhat Agree	Agree Completely
(1)	(2)	(3)	(4)	(5)

10. If you think your child may have a concussion, it is OK for them to continue to play hockey. (**Select one**)

Disagree completely	Somewhat disagree	Neither Agree Or Disagree	Somewhat Agree	Agree Completely
(1)	(2)	(3)	(4)	(5)

11. Given the choice, in what form would you like to receive educational information about concussions?
    a. Power-point
    b. Poster
    c. Pamphlet
    d. Flyer

Chapter 4: Manuscript
Concussion Knowledge of Missoula Youth Hockey Participants and Their Parents.

Key Points:

1. Youth hockey participants and their parents display a lack of knowledge regarding sport-related concussion.
2. Youth hockey participants and their parents desire comprehensive concussion education materials and guidance in their education process.

Abstract:

Background:
The Dylan Steigers Protection of Youth Athletes Act (DSPYAA) was passed by Montana legislature in 2013 which calls for mandatory concussion education of coaches, parents, and athletes. This law only applies to school sponsored sports, excluding those involved in youth sports organizations (YSO), such as youth hockey.

Hypothesis: Participating youth athletes and parents will not be able to identify signs and symptoms of a concussion and will not be able to identify future consequences of a poorly managed concussion.

Study Design: Cross sectional survey.

Level of Evidence: Level 4

Methods: A descriptive questionnaire, *Concussion Knowledge in Youth Sports Participants and Their Parents in Western Montana*, was distributed to participants during practice. Participants obtained using convenience sampling resulted in 25 athletes, average age of 11 $\pm$ 2.1 years, and 75 parents, average age of 41.9 $\pm$ 7.4 years. Due to the convenience sample, a response rate could not be obtained. The researchers combined and modified two existing validated surveys containing 4 closed ended questions with 32 options assessing concussion knowledge and one question on previous concussion education. Quantitative data from the questionnaire was analyzed using Microsoft Excel.

Results: The average composite score on the survey was 10.50 $\pm$ 3.48 (athletes) and 13.32 $\pm$ 2.59 (parents). More than 50% of parents (n=50/72) and athletes (n= 17/24) reported they had discussed the consequences of concussion with each other. Less than 50% of parents (n=21/72) and athletes (n=10/24) reported they had formal education about concussions.

Conclusions: Athletes scored well below previously reported composite scores of 16 on this survey, indicating a poor ability to recognize concussion symptoms and long-term consequences.

Clinical Relevance: Future implementation of concussion education programs for these organizations is highly suggested.

Key Words: Concussion, youth sports organizations, symptoms, future consequences

Introduction:

Concussion persists as one of the most prevalent sports-related injuries in the United States and abroad.[5] Each year, traumatic brain injury accounts for 2.5 million emergency department visits, hospitalizations and deaths in the United states. [5] Specific to sports related concussion, there are an estimated 3.8 million reported and unreported concussions in the United States each year.[15] Due to the complicated culture of sport, low levels of concussion knowledge for parents and athletes, and lack of medical resources, sport-related concussion presents a large problem.

Youth athletes participating in athletics prove to be one of the most vulnerable subsets of the population when it comes to concussion. The number of sport-related concussions in children ages 8-13 seen in the emergency department doubled from 1997-2007.[1] An even greater increase, 200%, was seen for the age group 14-19 years old.[1] With a large number of youth athletes participating in sport and a growing concussion rate, attention must be paid to the current state of Montana's youth athletics. Younger athletes have an immature nervous system along with decreased myelination, thinner frontal and temporal bones, a larger head-body ratio, and weaker neck muscles.[25] These characteristics alone, without considering the effects of contact sports and a culture of under-reporting, leave the youth population in a position of danger.

A lack of education pertaining to concussion signs and symptoms has been shown to contribute to under-reporting among youth athletes, as well as the improper care of an individual with a concussion.[3,13,18] Previous research indicates that concussion knowledge levels lie around the 50% mark, an alarming statistic when most policies rely on the ability of the athlete, coach and parent to identify concussion symptoms.[17] In Montana alone, less

than half of the high schools have a school nurse or athletic trainer to assist in this process, leaving concussion recognition to the previously highlighted groups (unpublished data, 2016).[22] With the current culture of resilience and toughness contributing to strong athlete identity and the lack of education amongst responsible parties, there is much to fear for the future of concussion identification and management.

Knowledge assessments and attitude assessments are frequently used tools in concussion education research.[2,9,10,12,16,18,28] They are often used as a device to assess where the healthcare field stands in the push for concussion recognition, reporting and proper care. On an essential level, a knowledge assessment can first demonstrate if the group being tested understands the basic components of concussion recognition and how failure to recognize these symptoms may result in extreme consequences. Beyond this, a knowledge assessment and an attitude assessment can provide insight into the decision to continue to play or the early return to play while symptomatic, attitudes and beliefs resulting from environmental factors, fear components during decision making, and risk assessments during decision making.[6,11,13, 27]

The significance of this study is rooted in discovering where participants and parents within the Missoula Area Youth Hockey Association (MAYHA) fall in their ability to identify concussion signs and symptoms and future consequences of a poorly managed concussion. By finding out the concussion knowledge level of Missoula youth hockey players, some light will be shed on the possibility of under-reporting due to lack of knowledge. Current research on concussion education has focused on the connections between lack of knowledge and under-reporting among youth, college and professional athletes. Although the relationship between knowledge and reporting remains unclear, it is

critical to recognize that the younger the athletes are educated on the ability to identify symptoms and the dangers of under-reporting, the greater the effect on concussion education retention and decision making.

Methods:

Participants: Participants in this study were playing on a MAYHA youth hockey team, one of the varsity high school hockey teams, or an 18-year-old on the Missoula junior hockey team. The MAYHA includes in-house, in-house select, and travel teams and the convenience sample consisted of youth players on a squirt team (10 and under) or older due to the 5th grade reading level of the survey. Of the 340 possible youth participants, this study was able to collect surveys from 25 youth players. Eligibility criteria for the parent sample required that they be a legal guardian of a participating youth hockey player in the MAYHA. With a possible sampling pool of 680 parents, assuming each athlete had two guardians, this study was able to collect surveys from 75 adult participants. Demographic information about the athletes and parents is presented in Table 1.

Instruments: Face and content validity were established for the survey instrument: *Concussion Knowledge in Youth Sports Participants and Their Parents in Western Montana*. Survey questions and content were based on previous studies assessing concussion knowledge and includes some, but not all, signs and symptoms of a concussion and future consequences of a concussion.[7,19,24,25] The survey contained two sections of 10 signs and symptoms, including distractors, followed by two sections of 12 future consequences, including distractors. Next there were two yes/no questions about formal education and parent/athlete communication about concussion. The remaining four questions used a Likert scale to assess attitude and viewpoints of the participants.[26] Five categories were

used on the Likert scale including: disagree completely, somewhat disagree, neither agree or disagree, somewhat agree, agree completely.[26] The final question was a multiple choice question regarding preferred education method.

Procedures: This study was approved by the University of Montana's Institutional Review Board for the Protection of Human Subjects in Research on August 7th, 2015. Once approved, we contacted the Missoula Area Youth Hockey Association board and Glacier Ice Rink (GIR) for permission to survey their youth athletes and parents. A block of time during a week of practices in February 2016 was selected as our sampling window. This window spanned a time where all teams would be arriving or departing from GIR. During the data collection athletes and parents were given consent and assent forms, as well as the survey and directions for completing the survey. The survey took approximately 7-10 minutes to complete and as an incentive for participating in the study, participants were given a ticket for a chance to win hockey gear, hockey skates, or a kindle fire.

Data Analysis: Data from each questionnaire was entered into Excel (version 2010; Microsoft Corporation, Redmond, WA). Descriptive statistics were used to determine the frequency of identification of each symptom and the consequence of concussion, as well as the percentage of participants who have received education from a formal source. The surveys were scored by calculating a composite score for each participant. This was done by coding the correct and incorrect answers for the symptom and consequence questions. Composite scores were generated by adding the total possible correct signs/symptoms and consequences and awarding 1 point for each correctly identified minus 1 point for each distractor selected. The final score calculated is the composite score. The total possible points on the survey is 22. Lastly, we evaluated the association between the education

received and the composite score with linear regression using SPSS (Version 22.0; IBM Corporation, Armonk, NY). Cronbach's alpha was used to assess internal consistency on the symptoms and consequences scale.

Results

Results: Surveys were tabulated to reveal an athlete average composite score of 10.5/22 ± 3.48 (47.7%), and a parent average composite score of 13.3/22 ± 2.59 (60.4%). Symptom identification selection (Table 2) and future consequence selection (Table 3) frequency varied between athlete and parent participants. Cronbach's alpha was assessed for responses on the symptoms scale resulting in: athlete Cronbach α=0.75, parent Cronbach α=0.78, combined subjects Cronbach α=0.80. Cronbach's alpha was also assessed for responses on the future consequences of a poorly managed concussion scale resulting in: athlete Cronbach α=0.32, parent Cronbach α=0.61, combined subjects Cronbach α=0.56. The coefficient of determination for education received and the composite score assessed with linear regression were: parent r^2=0.003, athlete r^2=0.372, combined r^2=0.05.

Symptoms: The symptoms most commonly identified by athletes as being signs and symptoms of concussion included poor balance n=25 (100%), ringing in ears n=22 (88%), and fatigue n=21 (84%). Following these symptoms, as being highly recognized as concussion signs and symptoms, were drowsiness n=18 (72%) and nausea and vomiting n=18 (72%). The signs and symptoms the athletes identified the least were sadness n=6 (24%) and irritability n=8 (32%). The most common distractors selected by the athletes were muscle spasms in your neck n=11 (44%) and epistaxis n=11 (44%).

Similar to the athlete participants, the parent respondents most frequently identified nausea and vomiting n=74 (98.6%), poor balance n=72 (96%), and drowsiness

n=71 (94.6%) as concussion signs and symptoms. Unlike the athlete participants, the next most commonly identified signs and symptoms for parent respondents were unlike any frequently selected by the athletes: vacant state/glassy eyed n=69 (92%), fogginess n=69 (92%), and sensitivity to light n=68 (90.6%). The least identified signs and symptoms were sadness n=33 (44%) and neck pain n=40 (53.3%). Among the parent respondents, the most frequently selected distractors included pale skin n=28 (37.3%) and muscle spasms in your neck n=28 (37.3%).

Consequences: The athletes surveyed did well in accurately selecting possible future consequences of a poorly managed concussion. Although persistent headache n=21 (84%), persistent dizziness n=20 (83.3%), and persistent sadness n=20 (83.3%) were the most frequent and correct identifications for athletes, more than 50% of the group correctly selected the other correct consequences. For distractors, persistent neck pain n=12 (48%) stood out as being more commonly selected then stroke, blindness, and persistent jaw pain.

The parent participants did well in selecting correct future consequences of a poorly managed concussion. The most successfully selected future consequence being persistent headache n=68 (90.6%) and least successfully selected being early onset Parkinson's n=34 (47.2%). At least fifty percent of the parent surveyed were able to accurately select the other future consequences. Unfortunately, many parents also over-selected the distractors for future consequences, most frequently increased risk of stroke n=52 (69.3%).

Education: When asked if they had received formal training about concussion, 41% (n=10) of the athletes responded yes. Comparatively, the parent participants only reported that 29% (n = 21) had previously received formal training on concussion. Despite this disparity,

both the athletes and parents, 70% (n=17) and 69%(n=50) respectively, reported discussing the risks associated with concussion with each other.

Influence of Education on Knowledge regarding SRC: To determine the correlation between the formal concussion education received and the composite scores of the participants, we utilized linear regression. The resulting r^2 values (parent r^2=0.003, athlete r^2=0.372, combined r^2=0.05) indicate a minimal and weak correlation between the two variables.

Discussion: Concussion is without a doubt an issue today in youth athletics. The rising number of youth athlete participants can be assessed as one factor contributing to the increase in incidence but there are other contributing factors that need to be addressed. A history of underplaying symptoms of concussion, a culture promoting toughness and perseverance, and an overall lack of necessary resources are not helping the cause. By assessing the current level of youth athlete and parental concussion knowledge, a step forward is taken.

Concussion attitude and reporting patterns may or may not be directly influenced by education. It has been found that 75% of athletes educated on concussion continued to play despite recognizing their symptoms and, that despite emotional testimony about the dangers of concussion, youth attitude towards concussion didn't change.[9,14] Hope lies in the idea that by reaching the athlete with education initiatives earlier in their athletic career and creating a cultural shift towards openness to report, a safer athletic environment can be created. Research shows that athletes ages 13 to 15 are most receptive to information about concussions.[2] By educating them on signs and symptoms of concussion we may see

fewer statements about their decision to not report because they thought their injury wasn't serious enough to require attention or that they didn't even realize they sustained a concussion.[14,20]

Overall, the athletes that responded to this survey were from the lower age group (average age=11). The question remains why avoidance of survey materials was seen in the older age groups present at the rink. What is known is that the athletes who participated demonstrate that they have a good foundation of concussion knowledge, ready to be expanded upon. Although they fell below a previously recorded average composite score of 16, they were able to correctly identify common symptoms such as poor balance, ringing in the ears, and fatigue.[7] Interestingly, both the athletes and parents surveyed less commonly selected emotion-related symptoms as signs of concussion, including sadness and irritability. The decreased selection of these symptoms indicates that, although the participants can recognize physical manifestations of concussion, there is still room to improve when identifying less discussed signs.

Parents and coaches have been identified as key players of concussion reporting and concussion management. Previous research highlights the fact that not all parents may be able to adequately recognize the signs and symptoms of concussion that their child may be presenting.[18] This study reveals the average composite score for the parents surveyed was above 50%. They frequently identified factors that are not always recognized, such as vacant stare and sensitivity to light, while effectively avoiding distractors. Distractors among the appropriate signs and symptoms were only incorrectly selected, at the most, by 37% of the sample. While these are positive findings, the fact that only 29% of parents

surveyed reported they have ever had formal training on concussion indicates that there is still room to improve.

Not only is it critical to identify concussions in youth athletics but it is also imperative to manage them properly. With future possible consequences of a poorly managed concussion such as second impact syndrome, chronic traumatic encephalopathy, Alzheimer's disease and Parkinson's disease being possible end results for these children, better attention must be paid to the concussion management process.[4,8] Not only is there distant future at risk, but so too is their immediate future. With up to 15% of children experiencing prolonged exercise intolerance, deficits in neurocognitive function, working memory and reaction time, there is a marked difference in the child's quality of life.[21,23] With early onset Alzheimer's, early onset Parkinson's, and death being the least frequently identified future consequences by both parents and athletes, there is concern that these populations are not adequately educated on the possible future consequences of concussion. The parents surveyed also tended to over-select the distractors in comparison to the youth athletes, furthering the idea of necessary future education.

This sample reported that they were discussing concussion with one another (athletes 70%, parents 69%). This is a critical piece in changing the culture of reporting by opening the lines of communication. Although this sample did well in discussing symptoms and future consequences, the intent of future education efforts should be to facilitate conversations that are composed of the most recent and up-to-date information. Results from this study show minimal correlation between formal education on concussion and the composite score of the participant. This indicates the need for future investigation into successful concussion education practices.

Limitations: There were limitations with this study. Utilizing a convenience sampling method, the response rate was lower than we would've liked and it largely included athletes on the lower half of the age range. Incorrectly signed assent and consent forms forced us to throw out a large number of completed surveys. The lack of parental attendance at practices for the older age groups made it difficult to obtain consent forms and, consequently, completed surveys. External validity is limited due to the inability of the study results to be generalized to alternate populations and other geographical locations. It is also important to remember that descriptive statistics and correlations do not provide causal information, just a better base of knowledge on the subject.

Conclusion: In the eyes of many, concussion may already be seen as receiving more efforts than necessary. While strides in research and technology are being made across the board, it can be easy to forget the clinical implications. Our youth require assistance in advocating for themselves. It is the responsibility of all parties involved to be educated on such a frequent health adversity such as concussion. While many may be willing and eager to learn, the educational resources must be available, comprehensive, and clear. Currently, formal concussion education does not correlate with the ability to recognize signs, symptoms, and future consequences of concussion. Future educational research should be rooted in identifying with and pertaining to specific athletic populations. The vulnerability of the youth population and their future success depends on exceptional avenues of education.

Clinical Recommendations:

Youth hockey athletes participating in a non-sponsored youth sport organization should be educated on concussion signs, symptoms, and future consequences.[4] (Sort Evidence Rating: B)

Parents of youth hockey athletes participating in a non-sponsored youth sport organization should be educated on concussion signs, symptoms, and future consequences.[4] (Sort Evidence Rating: B)

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Table 1: Demographic Data

Demographic Data Youth Hockey Participants and Parents			
	Age ± SD	**Gender**	**Years Played**
Athletes n=25	11 ± 2.1	F=3 M=14 (Incomplete: 8)	6.4
Parents N=75	41.9 ± 7.4	F= 28 M= 28 (Incomplete:19)	____

Table 2: Average selection of symptom identification for youth hockey athletes (n=25) and youth hockey parents (n=75)

	Average Signs and Symptoms Selected	
Symptoms	**Athlete (%)**	**Parent (%)**
Vacant Stare/ Glassy Eyed	56 (n=14)	92 (n=69)
Drowsiness	72 (n=18)	94.6 (n=71)
Nausea/ Vomiting	72 (n=18)	98.6 (n=74)
Irritability	32 (n=8)	72 (n=54)
Neck Pain	56 (n=14)	53.3 (n=40)
Inappropriate Emotions	48 (n=12)	74.6 (n=56)
Excess Sleep	52 (n=13)	80 (n=60)
Sensitivity to Light	60 (n=15)	90.6 (n=68)
Sensitivity to Noise	44 (n=11)	69.3 (n=52)
Feeling Like in a Fog	56 (n=14)	92 (n=69)
Poor Balance	100 (n=25)	96 (n=72)
Fatigue	84 (n=21)	76 (n=57)
Sadness	24 (n=6)	44 (n=33)
Ringing in Ear	88 (n=22)	84 (n=63)
Distractors	**Athlete (%)**	**Parent (%)**
Difficulty breathing	20 (n=5)	32 (n=24)
Pale Skin	28 (n=7)	37.3 (n=28)
Neck Spasm	44 (n=11)	37.3 (n=28)
Black Eye	16 (n=4)	21.3 (n=16)
Epistaxis (nosebleed)	44 (n=11)	28 (n=21)
Jaw Pain	20 (n=5)	36 (n=27)

Table 3: Average selection of future consequences of concussion following inappropriate care for youth hockey athletes (n=25) and youth hockey parents (n=75)

	Average All Sports	
Symptoms	**Athlete (%)**	**Parent (%)**
Early Onset Dementia	60 (n=15)	77.3 (n=58)
Persistent Dizziness	80 (n=20)	85.3 (n=64)
Death	52 (n=13)	73.3 (n=55)
Persistent Headache	84 (n=21)	90.6 (n=68)
Bleeding in the Brain	62.5 (n=15)	88.8 (n=64)
Early Onset Alzheimer's	54.1 (n=13)	55.5 (n=40)
Early Onset Parkinson's	50 (n=12)	47.2 (n=34)
Persistent Sadness	83.3 (n=20)	91.6 (n=66)
Distractors	**Athlete (%)**	**Parent (%)**
Increased Risk of Stroke	28 (n=7)	69.3 (n=52)
Persistent Neck Pain	48 (n=12)	53.3 (n=40)
Increased Risk of Blindness	33.3 (n=8)	44.4 (n=32)
Persistent Jaw Pain	33.3 (n=8)	43.0 (n=31)