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Self Reported Knowledge of Concussion Symptoms and Management by Middle and High School Club Lacrosse Coaches

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SELF REPORTED KNOWLEDGE OF CONCUSSION SYMPTOMS AND MANAGEMENT BY MIDDLE AND HIGH SCHOOL CLUB LACROSSE COACHES

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The game of lacrosse is one of the fastest growing sports in the United States today, with increases in participation of up to 80% in the past decade. This increase in participation has led to an increase in concussions diagnosed for both men's and women's lacrosse. With the number of diagnosed concussions on the rise, there is an increased reliance on trained medical professionals, coaches, parents and athletes to help in the recognition of symptoms. Many concussions still go unreported or undiagnosed either on purpose or as a function of inadequate medical coverage and knowledge of signs and symptoms by coaches, parents and athletes. Currently all states have some form of concussion legislation and are working towards improving the laws surrounding management of concussion as well as the educational requirements for medical professionals, coaches, parents, athletes. There is minimal evidence to suggest that educational materials and legislation impact overall athlete safety or the ability to recognize a symptomatic athlete. However, through further development of legislation and educational materials we can impart a change in the way we view concussion as a society, giving legitimacy to concussions as a true injury. The current study used a descriptive survey to examine concussion knowledge level of middle school and high school lacrosse coaches for men's and women's lacrosse. The results will be utilized to develop educational materials for coaches and may potentially impact state legislation surrounding concussion.

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Chapter 1

Statement of the Problem:

In the U.S., 1.6-3.8 million sport related concussions (SRC) occur annually during collegiate and high school sports, with approximately 50% of these coming from football and a minimum of 250,000 occurring in high school age athletes.[1,2] Evidence suggests that these numbers are lower than the actual incidence rate because of under reporting and an inability to recognize symptoms.[1,3] One study showed an increase in incident of SRC to be 16% across all sports with a 14% increase across men's sports and 21% increase across all women's sports.[3] Collision sports such as football and lacrosse contribute to a 300% higher prevalence in men versus women in the total number of SRC annually. In comparable sports, where the men's and women's games are essentially the same there was a 200% higher prevalence of SRC for women versus men.[3] It is also noted that there was an increase in total SRC and rate per 1000 athlete exposures (AE) across all sports for both men and women in 2005, coinciding with increased athletic trainer coverage in the programs surveyed.[3] This increase in ATC coverage correlates to the increased reporting and recognition of SRC.[3] The highest prevalence of concussion in high school sports is football (40.5%), women's soccer (21.5%), men's soccer (15.4%), and women's basketball (9.5%).[3] Collision sports account for the vast majority of all concussions with football and men's lacrosse accounting for 1651 of the total 1986 concussions across all men's sports surveyed in McCrea et al. study from 1998-2008.

In the world of athletics and athletic medicine, concussion has become a hot topic for discussion, specifically regarding the treatment and detection of concussion. The task of

identifying a concussion during a game or practice is not always straightforward, as there are many signs and symptoms that may not present for extended periods of time. The best precaution is to have medical professional at the event to properly assess an individual and determine if it is safe to return to play. Unfortunately, this is not always the case, as many high schools do not have appropriate medical coverage during school sanctioned sports and for club sports. A new study reported that 70% of U.S. public high schools have athletic training services, with only 37% having full time athletic trainers.[4] Forty-seven percent of schools provide full practice coverage every afternoon while 30% had no athletic training services at all.[4] In many leagues where there is no medical coverage at all, acute injury and safety are left to the coaches and referees, even in the absence of appropriate training or level of understanding.

Even with increased medical coverage at all levels of athletics, and the increase in awareness of concussion symptoms and dangers, there are still a large number of SRC that go undiagnosed and unreported.[3,5,6,7,8] In middle school and high school club lacrosse (grades 6-12) there is little coverage by medical personnel at games and almost none at all for practices. All of the burden of concussion recognition falls on the coaches during these times and so it is important that they are learning how to better spot concussions while medical coverage is not available. Coaches do not typically possess the appropriate medical education to effectively recognize and diagnose concussion, risking the player's health.[9,10,11,12,13] Resources are available for coaches but need to be examined for accuracy and depth of information as well as the platform from which that information is presented. In order to do this, investigation into the level of knowledge that coaches possess regarding recognition and treatment of concussion is needed.

Theoretical Framework:

The culture surrounding athletics supports the notion that an athlete should do anything to maintain their level of participation in their sport, even if this means not reporting an injury or playing through injury even if they know that they are at an increased risk of further injury by doing so.[14] Bandura's Social Cognitive Theory (SCT) can be applied to the athlete's environment as a primary influence on their reporting behavior either directly or by influencing their cognitions about expected outcomes or reporting and how other groups (coaches, parents, teammates and fans) value their response. SCT has an impact on the willingness to report injury further supporting the need for educated coaches, parents and athletes. Critical opportunities for positive reinforcement of an athlete's decision to report a SRC are often missed due to a lack of knowledge or a culture that does not emphasize health over participation. Providing educational materials and initiatives can combat this problem and much of that responsibility lies on others within the athletic environment.

Many athletes understand the dangers of SRC and the possibility for life-long impairment or death associated with it.[14] However, when provided with scenarios regarding concussion symptoms, 66% said they would continue to play and notify no one of their symptoms, while 33% suggested they would take a small break before returning in the same bout of competition or practice.[14] This demonstrates the barriers associated with reporting of SRC when faced with a participation decision while displaying symptoms of an SRC. In order to develop educational materials and protocols it is critical that we understand the reasons that athletes and coaches choose to not report or remove themselves or others with a suspected SRC from competition. Investigation will help develop educational materials and protocols to minimize the risk factors associated with SRC. Pressure from coaches, teammates, parents and fans all play an important

role in the underreporting of SRC. Athletes that have felt pressure from all four sources were significantly more likely to continue playing compared to athletes who did not experience pressure from all four or only from their coaches and teammates.[15] However, athletes that experienced pressure from from just one of the the four sources were 25% more likely to continue playing after a head impact that resulted in SRC symptoms.[15]

This type of behavior can be directly linked to the culture of athletics and the lack of knowledge among those who have the influence to shift this culture towards priority of health over participation.[15] Medical professionals working in athletics have a duty to protect their patients regardless of the social pressures to allow the athlete to participate. It is through education that we can start to impose a change in the culture surrounding SRC and injury and move towards a model where the health of an individual far surpasses the importance of their participation in athletics.

The level of knowledge and understanding of concussion needs to be improved across all sports, age levels and levels of competition.[9,10,11,12,13] This study aims to investigate and provide necessary understanding of how coaches knowledge can improve and to set the framework for further educational materials to better serve and educate our coaches on their role in prevention, recognition and response to SRC in young athletes.

Purpose of Study

The literature concerning SRC in sports indicates that there is a disconnect between current SRC knowledge and the knowledge possessed by coaches.[9,10,11,12,13]It also demonstrates that there are still many misconceptions regarding SRC that are still prevalent among

coaches.[9,10,11,12,13] Lack of knowledge may contribute to the underreporting and mismanagement of SRC by coaches that may lead to catastrophic outcomes if not addressed.[16,17,18,19,20]

The purpose of this study was to investigate the level of knowledge of SRC by high school lacrosse coaches and to understand current concussion education practices among this group. We investigated the coach's ability to recognize signs, symptoms and consequences of a poorly managed concussion, providing information to help build future educational resources for coaches. We hypothesized that coaches would demonstrate a poor knowledge of concussions and that they have received inadequate education or none at all.

In order to impose change in educational materials provided and their effectiveness we must investigate current educational models and determine what methods of presenting concussion information are most effective. Several studies have shown that some educational materials are decidedly ineffective at promoting any positive changes in practice of preventing, recognizing and managing SRC.[9,10,15,21] Following completion of this study, the data is intended for use in building a framework to provide high school club lacrosse coaches with tailored educational materials that provides information towards effective practices as well as the appropriate management of SRC. While the amount of active research involving SRC is growing steadily the need for comprehensive educational materials and initiatives is only growing in importance. There is a significant need to improve the knowledge of every individual involved in athletics to better understand the signs, symptoms and risks associated with participation while concussed.

Quantitative Research Question(s)

1. Are high school club lacrosse coaches able to correctly identify signs and symptoms of concussion?
2. Do high school lacrosse coaches understand the consequences of a poorly managed concussion?
3. Have high school lacrosse coaches received formal or informal education regarding concussions?
4. Does a relationship exist between education received and ability to recognize signs and symptoms of concussion?
5. Is there a difference between men's and women's lacrosse coaches in the effect of education on their ability to recognize signs and symptoms?
6. What is the most effective way of presenting educational materials on concussion to coaches?

Quantitative Hypothesis

1. We hypothesize that coaches cannot correctly identify the signs and symptoms of concussion.
2. We hypothesize that coaches do not adequately understand the consequences of participating while concussed.
3. We hypothesize that coaches have not received formal or informal education regarding concussions.
4. We hypothesize that there is positive relationship between receiving education and the ability to recognize signs and symptoms of concussion.

5. We hypothesize that there is no difference between men's and women's coaches on the ability to recognize signs and symptoms after receiving education material.
6. We hypothesize that formal education leads to better ability to recognize signs and symptoms as well as manage concussed athletes.

Significance of the Study

The significance of this study is to determine the level of concussion knowledge in middle and high school club lacrosse coaches. While the burden of concussion recognition and management does not solely lay with the coaching staff of a team, they are an indispensable asset when trained correctly. Public knowledge of concussions has grown at an unprecedented rate in the past two decades and many individuals that work in athletics have not taken the time to review and update their understanding of SRC. This makes it all the more important to provide relevant and effective methods of educating coaches, parents and athletes on the current state of concussion knowledge. Efforts to reach coaches with educational materials have increased but there is still a large portion of that population that has not received education based on our current understanding of concussions. Further research into the level of concussion knowledge that coaches have and the best ways to provide further education is needed and is the goal of this study.

Definition of Terms

1. Sport related concussion (SRC) — a sub-type of mild traumatic brain injury, occurs from an external force or blow to the head or body that causes an alteration in neurologic

functioning, with impairment in concentration, working memory and executive functioning.[22]

2. Traumatic brain injury (TBI) — Brain dysfunction caused by an outside force, usually a violent blow to the head.[22]
3. Mild Traumatic brain injury (mTBI)— Traumatically induced physiological disruption of brain function.[22]
4. Athletic Trainer (AT) — Health care professional who specialize in preventing, recognizing, managing and rehabilitating injuries.[23]
5. Athlete Exposures — A unit of susceptibility to injury, which is defined as one athlete participating in one game or practice, in which he/she is exposed to the possibility of athletic injury.[6]
6. Center for Disease Control and Prevention (CDC) — Federal agency that conducts and supports health promotion, prevention and preparedness activities in the United States with the goal of improving overall public health.[24]
7. Standardized Concussion Assessment Tool (SCAT) — Standardized method of evaluating athletes for presence of concussion.[25]
8. King-Devick (KD) — Based on speed of rapid number naming, requires saccadic (fast to target) eye movement.[25]
9. Standardized Assessment of Concussion (SAC) — A component of SCAT3, brief cognitive battery that captures domains of orientation, immediate memory, concentration, and delayed recall.[25]

10. Vestibular/ocular Motor Screening (VOMS) — assesses five areas of the vestibular and ocular systems: smooth pursuits, saccades (or rapid eye movement), vestibular ocular reflex, visual motion sensitivity and near-point-of-convergence distance.[26]
11. Balance Error Scoring System (BESS) — A component of the SCAT3, a brief balance exercise to determine balance deficits.[27]
12. Social Cognitive Theory (SCT) — portions of an individual's knowledge acquisition can be directly related to observing others within the context of social interactions, experiences, and outside media influences.[15]
13. Diffusion Tensor Imaging (DTI) — is a MRI-based neuroimaging technique which makes it possible to visualize the location, orientation, and anisotropy of the brain's white matter tracts.[7]
14. Magnetoencephalography (MEG) — a non-invasive neurophysiological technique that measures the magnetic fields generated by neuronal activity of the brain.[28]
15. Neurometabolic Cascade — Series of neurometabolic changes occurring in the brain after concussive brain injury.[7]

Delimitations

We surveyed coaches of men's and women's middle and high school aged lacrosse teams (grades 6-12). We limited our sample to active coaches in the following states: Washington, Oregon, California, Montana, Idaho, Colorado, Wyoming, Utah, Nevada, Arizona, New Mexico.

Limitations:

Limitations are present in all research and occur when outside factors influence the outcomes and validity of a particular study. Limitations effect the ability to apply the results to other populations and the reliability of the results of the study. Limitations for this study include

population size, expected knowledge outcomes, geographic limitations, individual experience and self-reported limitations.

Threats to Internal Validity:

Internal validity refers to the approximate validity used to infer a causal relationship between two variables.[29] It further describes the reliability of the results as an accurate description of the population surveyed in the particular study. The current study aimed to evaluate the level of concussion knowledge in high school aged club lacrosse coaches. Threats to internal validity arise when other possible causes of the observed effect are not eliminated or controlled.[29] Due to the variability in the age and experience of the sample surveyed, the results may not be generalized to all coaches at every level of the sport and may be more determinant of the experience and age of the coach surveyed. Sample size influences the internal validity of this study as low numbers of responses may lead to inadequate results when generalized across the whole population.

Threats to External Validity:

External validity refers to the ability to generalize study results to a broader population than the one used within the study. In order to generalize the results a randomization of the selection from a population must occur. This is not possible in most studies because of time, expense and effort involved. Threats to external validity include the age and experience level of the individual coach. Lacrosse is a fast growing sport but still in its infancy in many regions of the country, and may not be an accurate representation of the entire population of men's high school club lacrosse coaches, especially in areas that have a longer history of the sport. Accessibility of the population is a threat to external validity as many of the individuals sampled are selected due to their ease of access.[29]

Another threat to external validity is the effect of the research environment. Often the act of participating in a study influences the behavior and responses of the individual and may distort the result either intentionally or unintentionally. Data was collected by way of online survey. Upon completion of the survey, data was stored electronically and all participants remained anonymous with regards to their answers and their participation in the study.

Temporal validity, or the ability to generalize results across time, is a threat to external validity. As new resources are continually developed for educating coaches about concussion the results may not accurately describe the same population several years after this study takes place.[29]

Organization of Remaining Chapters

Athletics comprise a large role in many young people's lives with millions participating in competitive and recreational athletics annually. Athletics are important in many areas, by promoting positive health, intellectual growth and social skills outside of the confines of athletics. The inherent risk in sports increase the likelihood of injury to any participant, including risk of sustaining a concussion. With 300,000 sports related concussions resulting in hospital visits annually there is an obvious need for protecting young athletes in every way possible.[30,31,32,33] Sustaining a concussion may influence and impair cognitive and social development as well as academic success. To protect the young athletes of this country we must focus on a comprehensive multi-faceted approach involving coaches, parents, athletes and medical professionals to achieve the best possible ability to address concussions in athletics. This begins with education and changes in legislation that will require all parties involved to be educated in the most current and accepted practices regarding concussions and full coverage of athletic events by trained medical professionals.

Chapter 2

Review of the Related Literature

Overview

A concussion typically occurs when a direct impact to the head or an indirect impact to the body causes linear or rotational accelerations transmitted to the head.[7,19] These forces lead to disruption of the normal neurocognitive and neurobehavioral function of the brain as associated structures and physiological mechanisms are disrupted.[7,19] This disruption leads to a neurometabolic cascade of events that cause detectable symptoms and lead to a diagnosis of concussion in an individual. Known as the "silent injury", SRC effect 1.6-3.8 million athletes a year with an ever increasing prevalence across all sports. The need for improvement in the areas of recognition, diagnosis and management is evident and begins with the implementation of concussion legislation and development of educational materials.[11,20,31]

Physiology of Concussion

Following an event that imparts biomechanical forces to the brain, neurological signs and symptoms in the absence of macroscopic neural damage occur as a result of functional and microstructural injury to neural tissue. Functional injury refers to changes in cellular or physiological functions such as ionic shifts, metabolic changes and impaired neurotransmission. Microstructural injury refers to physical changes that are detected using advanced imaging techniques like diffusion tensor imaging (DTI).[7] The basic neurobiology of concussion is described as a neurometabolic cascade of events that results in bioenergetics changes, cytoskeletal and axonal alterations, impairment of neurotransmission, and an increased

vulnerability to delayed cellular death and chronic dysfunction. The physiology of concussion is further broken down into a specific progression, each phase leading to the next and further progressing the injury within the brain called the "neurometabolic cascade".[7]

Signs and Symptoms

Detection of signs and symptoms of concussion is difficult due to the broad spectrum of their presentation. Effective diagnosis of a concussion requires an individual to know and understand the different aspects of concussion including clinical signs and symptoms, cognitive impairment, and behavioral disturbances. Commonly reported symptoms include visual distortion, dizziness, drowsiness, excess or inability to sleep, being easily distracted, headache, inappropriate emotional response, irritability, loss of consciousness, disorientation, nausea/vomiting, nervousness, personality change, balance and coordination deficits, difficulty concentrating, ringing in ears, sensitivity to noise, sensitivity to light, sadness, feeling "in a fog", vacant stare/ glassy eyed.[23] Often, these symptoms may be caused by other factors and so the presence of these symptoms alone are not enough to diagnose an individual with a concussion, however, they do provide the initial indicator that further testing to rule out concussion is needed.[19,34,35,36]

Long term Consequences

Concussions have been linked to long term cognitive decline in some studies and in others it would appear there is no evidence that directly links concussion to long term cognitive changes.[7,27] Chronic changes in neurocognitive function have been observed in athletes that sustain repeated concussion and sub-concussive blows to the head (soccer, football, boxing).[7]

These repeated impacts have been shown to lead to Alzheimer's disease, Parkinson's disease, chronic traumatic encephalopathy (CTE), depression, dementia, migraine, post traumatic stress disorder (PTSD) and amyotrophic lateral sclerosis (ALS).[7,37,38,39,40,41,42] One study investigated the integrity of white matter tracts in the brain following concussion and also in athletes participating in collision sports that have never been diagnosed with a concussion.[7] In this study both groups showed changes in fractional anisotropy (FA) indicating that white matter tracts have been damaged. This was seen for up to 6 das post-concussion in adolescents with correlated symptoms.[7] FA is typically low in major neural fiber tracts, and seeing increased FA values indicates white matter disruption, which has been linked to a majority of neuropsychological deficit when using standard testing procedures.[7]

In the immature brain, concussion leads to deficits in excitatory neuro transmission, an impairment that is associated with a loss of experience-dependent plasticity resulting in long periods of memory deficits. Even when appropriate recovery time is allowed, restoration of memory function is not complete.[7,37,38,39,40,41,42]

Prevalence

Participation in high school athletics has been steadily rising over the past 40 years with over 7.5 million participants in the 2011-2012 school year.[5] Studies show that 1.6-3.8 million sport related concussions are reported annually.[1,3,5,6] Increased participation has lead to an increase in the prevalence of concussion; this was demonstrated in a recent longitudinal study of sport related concussion in a school district that had an increase from 0.12 per 1000 athlete exposures (AE) in 1997 to 0.49 per 1000 AE in 2007, a 4.2 fold increase.[5,6] A yearly increase of 15.5% was noted across all sports surveyed.[5,6] Analysis of emergency room visits at the hospital

show a 200% increase in this same time period.[5] Due to heightened awareness some of the increased prevalence is attributed to better recognition and reporting, although many researchers suggest that the numbers of reported concussions are still significantly lower than the actual number due to unreported incidents. This is demonstrated by sharp increases in recent years as medical coverage and concussion awareness has become a hot topic in athletics.[3,5,6,7]

Boys sports account for 54% of AE and 75% of all concussions, with football and boy's lacrosse accounting for far more than other sports. A comparative study of 9 high school sports across 100 schools showed that concussions represented 9% of all sport related injury, of these sports; football (41%) and girls soccer (22%) accounted for the most concussions. In boys sports, football accounted for over half of the total concussions while lacrosse was next, accounting for a significantly lower amount but still double any other boys sports.[6] In sports where boys and girls games are essentially the same girls have higher prevalence than boys do at ratios of 1.7 in basketball, 2.1 in soccer and 1.9 in softball/baseball.[6] Although helmets do not protect against concussion, the illusion of safety may be to blame for helmeted sports showing twice the increase in concussion rates compared to non-helmeted sports.[6]

We know that sustaining a concussion puts an individual at an increased risk of sustaining another one. Lincoln et al. reported that of the 2651 total concussions included in their study, 11% were repeat concussions with 231 athletes sustaining 2 concussions and 26 athletes with 3 or more during the course of the study. Among these athletes the mean interval time between incidents was 316 days with 19% occurring within 1 month of the previous concussion.

There are only a few studies that specifically investigate injury rates among high school lacrosse players. With its 170,000 participants it is still one of the smaller population sports yet it accounts for high rates and numbers of concussion. One such study collected data from 2008-

2012, with 1406 injuries occurring during this time period. Injury rates were much higher in games compared to practices (3.61 vs 1.23 per 1000 AE respectively) with concussions accounting for a total of 21.9% for boys and 22.9% for girls.[43] The rate of concussion was significantly higher in boys (0.50 per 1000 AE) compared to girls (0.35 per 1000 AE) with a majority of them being sustained during games, for both sexes.[43] In boys games there was a 7x increase compared to practice (1.23 vs 0.17 per 1000 AE respectively), and in girls there was a 5x increase compared to practice (0.78 vs 0.16 per 1000 AE respectively).[43] In boys lacrosse 74.4% were resultant of contact with another person while in girls lacrosse the most common mechanism was contact with a playing apparatus (stick or ball), accounting for 63.8%.[43]

In comparing the prevalence of SRC among men and women, we must consider the differences in culture surrounding sports and also the likelihood that the athlete, coaching staff or medical staff recognize and report SRC. Women have been shown to report SRC at a significantly higher level than men and also are less pressured by their respective sport to play through injury.[6] Much of the reasoning behind this is the cultural bias to protect women and to be much more lenient with allowing participation for injured men in similar sports and age groups. Several other factors contribute to the incidence of SRC including biomechanics, neurophysiological and sport specific differences. Biomechanical factors such as neck strength and head size and also the mechanism of injury are different between sexes.[1] Men's and women's lacrosse are quite different in the rules and style of play. Men wear full helmets and various padding for protection because it is legal to body check and also use the stick to strike the opponent. In the women's game there is no body checking allowed and players are only to contact the opponents stick with their own. These differences in the game lead to different mechanisms of injury (MOI) for SRC's sustained. The most common MOI for the men's game is

contact with another player or with the ground while in the women's game the most common MOI is contact with an opponents stick or the ball.

Diagnosis

Diagnosis of concussion is particularly tricky in younger populations where the brain is still growing and maturing.[44] Young individuals with immature nervous systems are more susceptible to concussion and the continued development causes problems with obtaining baseline testing to compare with if a concussion is suspected.[44] Studies have shown improvements in several areas of cognitive testing such as reaction time and working memory between ages 9 and 15.[44,45] These natural developments can cause potential cognitive impairment to not show up as the individual would now have a higher baseline score and so the reference score to compare to is no longer valid.

Diagnosis of concussion is done by using a multi-modal approach as no one test is conclusive enough for diagnosis on its own.[46] There is currently no consensus as to the most accurate test or combination of tests that diagnose concussions or manage their recovery times. Mccrory et al. suggest that the most important and clinically significant method of diagnosis is by comparing to the individuals own baseline scores for any number of diagnostic tools. They further suggest that in the periods of most rapid cognitive development (ages 8-15) that new baseline scores be recorded every 6 months.[46] This is ideal, but not practical or possible in many settings due to financial or time restrictions.

While there is no single "go to" test, utilizing a combination of several diagnostic tools can increase the certainty that an accurate diagnosis has been made. Several of these tests are the

Sport Concussion Assessment Tool (SCAT3), Standardized Assessment of Concussion (SAC), King-Devick (K-D) and vestibular/occular motor screening (VOMS).

Each of these is a useful tool for diagnosing concussion but should not be relied on as a stand alone tool. SCAT3 is comprised of 3 sections: Balance Error Scoring System (BESS), SAC, and a 22-symptom list that allows for grading of each symptom from 0-6. The SAC includes orientation, memory recall both immediate and delayed, and concentration exercises. K-D is a sheet with spaced out numbers and a line indicating the direction it is meant to be read. It tests the ability to rapidly move the eyes, interpret, and read the numbers correctly as fast as possible. K-D is a short test and is helpful by testing cognition coupled with physical ability to rapidly move the eyes while maintaining focus on the next number.

VOMS is relatively new and also involves the eyes. In some research a 90% accuracy at diagnosing or ruling out concussion was reported.[26,47)] VOMS tests 5 areas of the vestibular and ocular systems: smooth pursuits, saccades (rapid eye movement), vestibular ocular reflex, visual motion sensitivity and near point convergence. The main drawback is that it takes an experienced clinician to administer as they must watch the patient's eyes for inadequate or inappropriate eye movement. This is just another tool that is utilized to further ensure diagnostic accuracy when evaluating an individual for a concussion.

Currently, research into direct biological detection through blood tests and advanced imaging is moving diagnostic tools away from the subjectivity of many of the clinician administered testing instruments. These new developments are far from viable in most settings as time, access and cost are still preventative factors for most schools and independent institutions. Several of the imaging techniques, including DTI and magnetoencehaplographic imaging (MEG), are promising techniques that may help to provide insight into the pathogenesis of

concussion in a patient as well as further investigate RTP and RTL guidelines by further assessing the healing process and where an individual is on the spectrum of recovery.[48] Blood tests are also being developed to detect biomarkers in the blood and serum that directly indicate concussion, though the assessment tools are not readily available and would require time and significant cost in order to be utilized. Further development in the areas of neural imaging and biological testing may lead to better detection and diagnosis of SRC in the future

Management

Inability to recognize and diagnose concussion are primary factors to the mismanagement of concussion in sports, and this is seated in the lack of education on the current state of concussion evaluation. The most common reason of variation in management protocols of concussion is lack of awareness, and confusion about the published guidelines for concussion.[19] In the past 30 years a shift in clinical strategies has gone from heavy reliance on anecdotal evidence to international consensus-based approach to identification, management using evidence-based strategies to inform education, and clinical practices.[19] When a SRC is diagnosed the next step is appropriate management to ensure the athlete is not returned to play (RTP) or returned to learn (RTL) earlier than they should be, possibly exposing them to situations that increase the risk of further health complications.[17,19,20,26,33,34,49] Education on management of concussion is paramount to the successful recovery and return to sport and activities of daily living for any individual that has suffered a concussion. The literature shows that younger individuals require a longer period for recovery, increasing the need for coaches, parents, athletes and medical providers to stay current with concussion knowledge. An individual that has a concussion should follow a staged progression to ensure symptoms do not return or become

exacerbated by cognitive stress or physical stress, both of which prolong recovery and cause symptoms to return even if the individual was asymptomatic at the beginning of a task. The current consensus on RTP guidelines stipulates that a coach shall not make the final decision on returning a player to competition, instead this decision should fall on medical personnel such as an ATC or physician[17,19,20,26,33,34,49]

Return to Play and Return to Learn

Return to play guidelines have been based on the biomechanical concepts of concussion since the first reported RTP rule was implemented. This was the called the "three strike rule" introduced by Quigley in 1945. This rule recommends that three concussions are grounds for termination of future sport participation. This rule was created to prevent catastrophic injury and the cumulative effects of repeated concussions.[19] This rule is no longer the standard for concussion management but the driving force behind its inception is consistent with today's motivations for establishing RTP guidelines.

An athlete with a concussion should be completely free of any post-concussion symptoms, both at rest and during exercise, before they are allowed to RTP. It has been unanimously agreed upon that an athlete should never RTP the same day as the concussion occurred. Data showing high school and collegiate athletes allowed to RTP on the same day may demonstrate elevated neuropsychological deficits post-injury that may not be apparent until after the event, and are more likely to have delayed onset of symptoms.[19,44] A consensus statement on RTP guideline was created at the 4th International Conference on Concussion in Sport, laying a framework for graduated return to play:

1. No Activity

    a. Symptom limited physical and cognitive rest
    b. Objective: recovery
2. Light Aerobic exercise
    a. Walking, swimming, stationary cycling at <70% of maximum heart rate
    b. Objective: Increased HR
3. Sport specific exercise
    a. Training drills that would be normally used in the sport. (skating for hockey, running for soccer)
    b. Objective: Increase HR and add movement
4. Noncontact training drills
    a. Progression to more complex training drills (route running in football)
    b. Objective: Exercise, coordination and cognitive load.
5. Full contact practice
    a. Following medical clearance, participation in normal training activities
    b. Objective: Restore confidence and assess functional skills by coaching staff
6. Return to play

This graduated progression to RTP is meant to be a guideline, but when managing SRC, individualization of management is important as no two athletes are the same and no two concussions are the same.[19] In this model, each step requires 24 hours in between completion and the athlete must be asymptomatic at the current level in order to progress. Should symptoms return at any one level, the athlete must return to the previous asymptomatic level, wait 24 hours and attempt to progress again.[19,44] It should be noted that pharmacological intervention for prolonged symptoms are becoming more prevalent.[44] In order to RTP, an athlete should not only

complete this graduated approach but also should not be taking any pharmacological agents/medications that may mask or modify symptoms of concussion prior to returning to play.[44]

Return to learn, or more specifically ending of the cognitive rest period, is another important aspect of concussion management that requires coordination and cooperation of parents, coaches, athletes, and school administrators. A period of cognitive rest is important to allow for recovery immediately following a concussive injury. It is recommended that an individual not participate in their normal work or school activities along with disengagement from social events and avoidance of electronic devices like computers, cell phones and video games. Once asymptomatic, an individual should gradually reintroduce tasks that are more cognitively taxing while being attentive to not trigger symptoms. For students this means a trial of cognitive activity at home or with school related work to determine if they can complete a full school day or return to full participation in school related activities and assignments.[33]

Legislation

Legislation surrounding concussion is important, not just in the diagnosis and implementation of protocols for management, but also in the development and distribution for educational materials for coaches, parents and athletes alike. The Korey Stringer Institute has developed 9 guidelines for state concussion policies and have graded each state based on their inclusion of each guideline in their concussion legislation. Currently there is not a single state that meets all 9 of these guidelines, only 3 that meet 7-8 of the guidelines while all 47 other states adhere to 1-4 of the recommended guidelines. All 50 states do have some form of legislation in place regarding SRC, and these laws should be viewed as living documents and

modified as further research into concussion is provided.[30] The guidelines provided by the Korey Stringer institute are:

1. Schools should develop an Emergency Action Plan (EAP) for handling potentially life-threatening injuries and a referral plan for concussions.
2. Use certified helmets/equipment.
3. The PPE (preparticipation exam) should include concussion specific questions.
4. Preseason education for personnel, coaches, and athletes (should be tailored to the group being taught, strongly recommend educational materials for parents) on basics of concussion (i.e. that helmets do not prevent cerebral concussions, signs/symptoms, treatment, testing options, RTP).
5. High school athletes suspected of sustaining a concussion are not permitted to return to a practice, game, or activity involving exertional activity on the same day.
6. Athletes suspected of a concussion are not permitted to return to participation until written release from a licensed physician or athletic trainer.
7. No child/adolescent should return to sport/activity unless he/she has managed to return to school.
8. Implementation of a graduated return to participation protocol (see Zurich/AMSSM example, at least 5 steps, no more than 2 in one day).
9. Comprehensive medical-management plans for acute care of a potential head or cervical spine injury.

These guidelines are important and should be included in any concussion legislation adopted by any state or institution to ensure all parties involved are providing the best care for an individual with a concussion. The Zachary Lystedt Law was signed into Washington state law in

2009, and is one of the first pieces of legislation passed regarding SRC.[50] This law requires coaches, parents and youth athletes be educated about concussions and sign a "concussion and head injury information sheet" prior to participation.[50] A key component of this is providing education for coaches, parents and athletes that is tailored to the sport or population. Legislation like the Zachary Lystedt Law has opened the door for research into the effectiveness of education and law surrounding SRC. A survey of parents and coaches one year after the implementation of the Zachary Lystedt Law showed a positive effect of education on both party's awareness of concussion symptoms, management strategies, and law, however a gap in this knowledge exists when parents and coaches of club sports were surveyed.[50] Club sports do not fall under the same coverage or regulations as school sanctioned sports and so the stipulations of state legislation do not directly apply to the coaches, parents, or athletes. This is a problem for lacrosse communities as many lacrosse programs are club sports, especially in the western United States where the sport is in its infancy. This can be addressed through changes in the effective areas of legislation. For example, in Oregon, everyone must wear a bike helmet under the age of 16 and this is enforced by requiring helmet use while on any public property. The same stipulations could be required by state law by requiring all participants of athletics on public fields and venues to complete concussion education the same as school sanctioned sports. While this still leaves private venues out of the scope of this type of legislation, it would address the many club teams that utilize public school fields and facilities. This is analogous to education requirements for individuals utilizing public fields or practice facilities because they both require a specific level of precaution to prevent potential injury. In one case it is a helmet and in the other it is concussion education, both of which are aimed at preventing and/or minimizing the extent of injury.

Education

When we consider all of the different factors involved with recognition, diagnosis, and management of concussion we can see that education is the key factor. Without education that is up to date and current we cannot expect parents, coaches, athletes or medical providers to adequately address SRC. There is variance in the ways that educational materials are provided and the information contained in those materials.[18] Consequently, the level of understanding following the different forms of concussion education is also variable and not always inline with the current consensus derived from research. One study reports that over 95% of coaches feel familiar or somewhat familiar with their state guidelines, while only 31% are familiar with the consensus statements. Valovich-McLeod et al. found that coaches that completed a coaching course or workshop on concussions were more likely to correctly identify and report signs and symptoms of concussion, supporting the need for further education.[51] We will differentiate into two groups for the type of education received, formal and informal. Formal education includes in person training such as classes or presentations by a trained professional and online classes. Informal educational materials include pamphlets, flyers, infographics, podcasts, videos, social media, posters, online resources, phone and computer applications. The main effect of educational materials is to provide the best information possible to all parties involved in recognition, diagnosis and management of SRC. Research into how effective different educational materials are has been conducted and suggests that while many do receive education, and there is some positive effect, not all of the educational materials are of the same quality or create the same effect on knowledge and understanding. Naftel et al. showed that 90% of ATC's have undergone formal concussion training while only 40% of coaches have received the same education. Given the inconsistency between ATC and coach education, refocusing of efforts to

better educate coaches should be a priority.[20] Only 31.5% of coaches and 50.9% of ATC's provided preseason information on concussion and even fewer used the Heads Up toolkit from the CDC. The Heads Up toolkit is widely accepted as an appropriate educational tool for parents, coaches, and athletes alike and it has been shown to improve identification for concussions.[31] Research into knowledge transfer (KT) has been conducted to further investigate the influence of education on retention and implementation of information provided. KT is defined as "the exchange, synthesis, and ethically-sound application of knowledge within a complex system of interactions among researchers and users to accelerate the capture of benefits of research."[11, pg. 2] KT principles are used to develop knowledge creation and application methods and involve exchanges and interactions between researchers that create and use the knowledge.[11] Use of models like KT are extremely important for future development of the most effective educational materials. The KT model provides the basis for the knowledge-to-action (KTA) framework that may help develop better educational materials. KTA involves two parts: knowledge creation, and action.[11] Knowledge creation is research based and involves refining, and tailoring to the needs of knowledge users and requires collaboration between the knowledge creators and users.[11] The action cycle involves the application of knowledge to achieve the desired changes in the focal group or population.[11] To put knowledge into action several steps need to be taken:

1. Identification of knowledge need.[11]
2. Adaptation of knowledge for the context of use to facilitate acceptance.[11]
3. Assessment of barriers and facilitators that influence the knowledge and the users of the knowledge.[11]
4. Identification, modification and implementation of interventions to promote and facilitate the implementation of knowledge.[11]

5. Observation of knowledge use.[11]
6. Evaluation of impact to determine if knowledge use made a difference on the desired outcomes.[11]
7. Implementation of a plan to sustain knowledge over time and in changing environments.[11]

The use of models like KT and KTA are of the utmost importance for further development of educational materials and the implementation of the information they provide. Multiple studies have shown the positive impact of receiving some form of education, while others show that the quality of education is just as important. This supports the need for further development and more widespread dissemination of concussion education materials like the CDC's Heads Up toolkit.

Chapter 3

Method

Overview:

The use of questionnaires or surveys has become an increasingly viable method of research in the athletic training field.[52] Research utilizing surveys involves self-reporting by way of self-administered questionnaire to gather data specific to a population. A six step process exists for survey research, establishing a pre-set plan of action for any research survey design. This plan of action includes: development of research questions and hypothesis when applicable; investigation of existing literature; clarification and refocus of research questions when appropriate; establish validity of instrument, determine the sample; and acquire and analyze the data.[52] If done correctly, survey research can be just as beneficial and valid as experimental-design research, and can be important and useful to a larger group than just the individual or group collecting the data.[52]

Population Size/Characteristics

It is estimated that participation in lacrosse has grown by 80% across all levels of competition and nearly doubled in middle and high school programs.[53] There are 8 regions that US Lacrosse divides the country into with a total of 68 chapters. We surveyed the Pacific and Mountain Regions which contain 13 separate chapters. We estimated there are at least 800 lacrosse coaches in these regions.[53] Participants were asked to complete the online survey distributed to league and district administrators.

Participants, Selection-Eligibility Characteristics, and Sampling

Our sample consisted of Men's and Women's lacrosse coaches for grades 6-12 who are registered with US Lacrosse, the governing body of men's and women's lacrosse in the US, and planned on participating as a coach in the upcoming 2017 lacrosse season. Approximately 400 teams with at least 800 coaches were expected to participate in the 2017 season across the pacific and mountain districts (Oregon, California, Washington, Nevada, Montana, Idaho, Wyoming, Colorado, New Mexico, Arizona, and Utah). Our estimated sample size corresponding to the number of coaches is $n = 240$. We estimated that 30% of coaches would participate allowing for appropriate analysis and external validity of our findings. There was no required length of time coaching or playing, nor was there an age restriction. Surveys were distributed to the president of each district within each state and prior to the start of the spring season. A contact list was populated from the district website and individual emails to each coach were sent by the creator of the survey to the coaches who's district president did not choose to participate in distribution.

Quantitative Instruments:

We utilized a single survey to gather data regarding concussion identification and knowledge of lacrosse caches for teams of grades 6-12. The survey is titled Concussion Knowledge in Lacrosse Coaches(CKLC) The survey consisted of 16 closed ended questions developed using literature and current research.[52] The signs and symptoms were taken directly from the CDC's "Heads Up" educational materials and the textbook Principles of Athletic Training 15th Edition.[23,31] The purpose of this survey was to gather data on the educational level of men's and women's lacrosse coaches of teams for grades 6-12. This information will be used

to provide a framework for future educational materials to provide these coaches with the best and most current information regarding concussion recognition and management.

The first section contained 2 questions that asked the participant to correctly identify symptoms of concussion. Each had a list of 10 possible choices with 2-5 incorrect answers imbedded in each list. The second section contained 2 questions pertaining to consequences of inappropriate care. Each question had 6 possible answers with 2 incorrect answers imbedded in the list. Section three contained 8 questions regarding the coach's perceptions of their own knowledge and willingness to act if a SRC was suspected. These questions included: have you talked about the consequences of a concussion with your athletes; I understand the dangers of concussions; I know the signs and symptoms of a concussion; If one of your athletes hits their head and has a headache, it is OK to continue to play the same day, as long as they didn't lose consciousness (i.e., black out); If I think one of my athletes may have a concussion, it is OK to continue to play sports the same day; helmets are designed to protect athletes from concussion; do you feel comfortable talking to athlete/parent about the dangers of return to play(RTP); do you feel comfortable talking to teachers/principal about return to learn (RTL). The fourth and final section consisted of 5 questions pertaining to education received by coaches and what method of education serves them best. The survey was distributed and completed prior to the start of the 2017 spring lacrosse season.

Developers of Instrument

Development of this survey was done by surveying of the current literature, personal experience by the developers, and by comparing questions to other surveys aimed at measuring similar metrics of different populations. Literature provided the basis for the most common signs

and symptoms associated with concussion. We modified our survey from Cournoyer et al. and Covassin et al. articles to develop questions pertaining to sign and symptom recognition, consequence recognition, and education.[1,54] We utilized another survey that measured knowledge of parents and athletes of high school soccer players for several of the questions as well as the overall format of our survey. Experience in the field of athletic training provided further influence into the development of the questions.

Administration, Scoring/Tabulating, and Interpretation

The first two sections were compositely scored by adding up the total correct answers and analyzing the total score as an indicator of the coach's overall level of knowledge pertaining to recognition of signs and symptoms and also consequences associated with SRC. There were 21 possible points with +1 point for every correct answer and -1 point for every distractor selected, while failure to select a correct answer resulted in 0 points. The sum of correct and incorrect answers provided the composite score. We utilized Cronbach's α score to determine reliability of our findings. Cronbach's α is an indicator of internal consistency reliability and is only relevant to composite scoring.

Development Procedures for Any New Instrument

This research project was survey driven, making development of the questionnaire and validation of its contents of the utmost importance to the success of this study. There were two major parts to development of a survey: deciding what questions to ask, and how to ask those questions once identified.[52] Most of the questions on this survey assess the participant's beliefs, behaviors and attributes. Questions pertaining to beliefs were aimed at determining what

participants think about a specific fact or topic of interest.[52] Behavior questions were utilized to determine how participants believe they behave in the presence of a certain situation of circumstance. Unfortunately, due to the inability to directly observe the participants, we could not ensure honesty with questions regarding behavior, and was a weakness of the research survey design.[52] Attribute questions were also included in order to determine demographic information about the respondents for later use by the researcher during data analysis.[52]

When writing survey questions each method of questioning requires different analytical considerations due to the different ways that gathered data can be utilized to determine outcomes from each question or set of questions.[52] Utilization of open and closed ended questions along with scaled questions represented the vast majority of survey driven data collection methods.[52] Our survey included closed ended questions as well as scale methods for data collection. Athletic training literature commonly utilizes closed ended questions with predetermined answers or sets of answers.[52] This allows for the researchers to analyze the data and maintain consistency in the survey responses.[52] Likert scales were used as analytical methods and are one of the most commonly utilized scales in athletic training literature.[29,52] Likert scales are summative and are used to assess attitudes or values. Responses are typically divided into 5 categories: strongly agree, agree, neutral, disagree, and strongly disagree.[29,52]

Validation Procedures for Any New Instrument

When reporting findings of a study, accuracy is of the utmost importance as it allows for others to utilize the findings to inform practice and direction of future research efforts.

Validation of a survey prior to its use is essential to ensure accuracy of data collected and conclusions derived from it.[52] Validation ensures that the data captured is an accurate

representation of the sample and will be appropriate for answering our research questions.[52] Survey research requires 4 assessments of validity: face validity, content validity, construct validity and criterion-related validity.[52] Without passing these assessments, a survey is not considered valid and the utilization of data and findings associated with it are not accurate.[52]

Face validity is an evaluation by experts and sample participants to determine if the instrument measures what it is intended to measure.[52] Face validation is subjective and considered the weakest assessment method, however, it is imperative in the development and validation of a survey.[52] The survey was first administered to a small group of coaches fitting our inclusion characteristics. Average time to completion was be recorded and participants provided feedback on the content and composition of the survey. A group of concussion experts also reviewed and provided feedback on content and composition of the survey.[52] We distributed the survey to a pilot sample of 2 lacrosse coaches and also 2 athletic training faculty at the University of Montana who completed the timed survey and reported back to the developers with feedback on the content and layout. This established content-validity of the survey by allowing experts in the area covered by the questions.[29] For our pilot we utilized 2 experts athletic training that reviewed the medically significant portions of the survey, while the lacrosse coaches aided in review of the education and overall applicability of the questions to the field of lacrosse.

Content validity, also know as internal validity, is reliant on, at least, one expert review of the instrument to determine if the questions included address all essential aspects of the study.[29,52] Utilization of a panel of experts further strengthens the content validity and ensures that the instrument satisfies the content domain.[52] Construct validity and content validity are closely linked, with the former representing a more abstract and basic validation of a survey.[29,52] As experts determine content validity they are also accepting the construct validity underlying

the content.[52]

Criterion-related validity is the fourth and most objective approach to determining validity of a survey.[52] This assessment of validity is important for determination of the concurrent and predictive validity of the survey results. Concurrent validity is determined by demonstrating that the results from one instrument correlate with results from an existing instrument.[52] Predictive validity is established by determining that a measure will be able to validly predict a future criterion score. Predictive validity provides rationale for using a specific measurement as a predictor of outcomes and is essential in clinical and educational decision making.[52]

Quantitative Procedures

Ethical Nature of Data Collection

All participants and their data were collected and utilized in agreement with ethical standards for human research. We anticipated no discomfort or inherent risk for the participants due to the methods of data collection and survey distribution. Completion of the online survey implied consent; no minors were anticipated to participate though in the event of minor participation a consent form must be signed by the individual's parent or legal guardian. Institutional review board approval was received prior to any data collection.

Time Line for Data Collection

The time line for our data collection was determined based on the best time for reaching the sample population as well as the time restrictions placed by school requirements for completion.

- December:
    - Proposal

    - IRB submission
- February: IRB Approval received
- March:
    - Data collection
        - Initial distribution: March 3rd
        - Follow up: March 14th
        - Final follow up: March 30th
- April :
    - Analysis of data
    - Presentation of data

Research Paradigm

A research paradigm is based on a set of assumptions, concept, values and practices that are held by a community of researchers.[29] The paradigm associated with any study determines the approach to thinking about and conducting the research associated.[29] For this study we utilized a *quantitative* research paradigm, relying on collection of quantitative data and focusing on the deductive component of the scientific method. Quantitative research, sometimes referred to as *confirmatory*, aims to test and provided data to support or reject a hypothesis or theory proposed by researchers. We chose a quantitative approach because it allowed objectivity in analysis of the data along with providing generalizable findings in an attempt to describe, explain and predict outcomes.[2]

Research Design (with justification)

We used a cross-sectional research design for this study. Cross-sectional designs are primarily used to estimate the prevalence of an outcome of interest for a specific population, often utilized for public health planning.[55] Cross-sectional designs utilize surveys as basis for description of a population with respect to an outcome or set of risk factors and any association between them.[55] Cross-sectional studies provide a "snapshot" of the outcome and associated characteristics with respect to the specified population. This allows the investigators to observe a specific point in time but limits the ability to make causal inference because there is no indication of the sequence of events preceding data collection.[55] This is a primary limiting factor when using a cross-sectional research design. Another limitation is that they only provide data related to one point in time. If the same data were collected in a different time-frame the outcomes may also differ.[55]

Quantitative Analysis

Data was collected and entered into Microsoft Excel for analysis. Descriptive statistics were used to determine the frequency and accuracy of symptoms identification and the consequences of concussion along with the percentage of participants that received formal or informal education and the format of the education received. An overall score was generated based on the percentage of correct answers and we assessed any overall association between composite score and education received with linear progression using IBM SPSS version 22.0. Cronbach α was calculated to assess reliability of signs and symptoms scale as well as consequences scale.

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University of Montana
ATHLETIC TRAINING
Rising Above

Concussion Knowledge in Lacrosse Coaches grades 6-12

Coaches Survey

What grade level team do you currently coach? (Circle all) 6 7 8 9 10 11 12

Is your team affiliated with a school? (Circle one) Yes No Both

How many years have you coached this sport? ____

Which sex do you coach? Men's Women's Both

1. Which of the following are symptoms 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
   f. Neck Pain
   g. Inappropriate emotions (out of place feelings)
   h. Pale skin
   i. Excess Sleep (sleeping longer than usual)
   j. Sensitivity to light
2. Which of the following are symptoms 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 or low energy
   h. Jaw pain
   i. Sadness
   j. Ringing in ears
3. Which of the following do you think are consequences of inappropriate care of a concussion? **Please circle all that apply.**
   a. Early onset dementia (impaired thinking)
   b. Increased risk of stroke
   c. Persistent dizziness
   d. Persistent neck pain
   e. Death
   f. Persistent headache

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4. Which of the following do you think are consequences 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 jaw pain
    f. Decreased athletic performance

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

6. I understand the dangers of concussions. (**Circle one**)

Disagree completely	Somewhat disagree	Neither Agree Or Disagree	Somewhat Agree	Agree Completely

7. I know the signs and symptoms of a concussion. (**Circle one**)

Disagree completely	Somewhat disagree	Neither Agree Or Disagree	Somewhat Agree	Agree Completely

8. If one of your athletes hits their head and has a headache, it is OK to continue to play the same day, as long as they didn't lose consciousness (i.e., black out). (**Circle one**)

Disagree completely	Somewhat disagree	Neither Agree Or Disagree	Somewhat Agree	Agree Completely

9. If I think one of my athletes may have a concussion, it is OK to continue to play sports the same day. (**Circle one**)

Disagree completely	Somewhat disagree	Neither Agree Or Disagree	Somewhat Agree	Agree Completely

10. Helmets are designed to protect athletes from concussion. (**Circle one**)

Disagree completely	Somewhat disagree	Neither Agree	Somewhat Agree	Agree Completely

11. Do you feel comfortable talking to athlete/parent about the dangers of RTP.(**Circle one**)

Disagree completely	Somewhat disagree	Neither Agree	Somewhat Agree	Agree Completely

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12. Do you feel comfortable talking to teachers/principal about Return to Learn protocols for your athlete following a concussion? (**Circle one**)

Disagree completely Somewhat disagree Neither Agree Somewhat Agree Agree Completely

13. Have you ever had formal education about concussion? (select all that apply
    a. Class (in person or by correspondence)
    b. Online course
    c. Presentation by trained professional
    d. Other _____

14. Have you ever received informal education about concussion? (select all that apply)
    a. Pamphlet
    b. Flyer
    c. Poster
    d. Online resources
    e. Infographic
    f. Podcasts
    g. Phone/computer application
    h. Video
    i. Social media
    j. Other _____

15. As a coach what do you believe the is best way to present educational info to athletes/parents about concussions?
    a. Power-point
    b. Poster
    c. Class (in person or by correspondence)
    d. Pamphlet
    e. Online course
    f. Flyer
    g. Presentation by trained professional
    h. Infographic
    i. Podcasts
    j. Phone/computer application
    k. Video
    l. Social media
    m. Other _____

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16. Given the choice, in what form would you like to receive educational info about concussions?
    a. Power-point
    b. Poster
    c. Class (in person or by correspondence)
    d. Pamphlet
    e. Online course
    f. Flyer
    g. Presentation by trained professional
    h. Infographic
    i. Podcasts
    j. Phone/computer application
    k. Video
    l. Social media
    m. Other _____

Manuscript

TITLE: Self-reported knowledge of concussion symptoms and management by middle and high school club lacrosse coaches

AUTHORS: Logan Ellis

BACKGROUND: With an increase in sport participation across all levels, concussion prevalence has increased as well as reliance on coaches to recognize a concussed player. Little research has been done investigating how effective our current educational materials are with Lacrosse coaches of grades 6-12.

STUDY DESIGN: Cross- Sectional

LEVEL of EVIDENCE: Level 4

METHODS: Self-administered, online survey that included closed ended questions regarding recognition of signs and symptoms, consequences of inappropriate care, perception of own knowledge, and willingness to act.

RESULTS: Among participants, an average composite score of 13/21 (62%) among all coach's surveyed indicates a low level of functional knowledge with regard to concussion symptoms and consequences. Cronbach's α analysis for symptom and consequence recognition yielded α= 0.734 and α= 0.631, respectively. Almost all participants have received either formal education (94%, n=63) or informal education (96%, n=64) with 82% (n=55) of those taking the initiative to talk with and educate their athletes about symptoms and the dangers of playing with a concussion. Linear regression for coach education source was calculated for formal education (r=0.10) and informal education (r=0.14) indicating that the form of education did not have a significant effect on the participant's ability to recognize signs and symptoms. A linear

regression was calculated for years of coaching experience (r=0.04) and did not have a significant effect of composite score.

CONCLUSION: Sport related concussion (SRC) is a serious health issue, and due to inadequate medical coverage and educational models for coaches, the lacrosse community is not able to provide effective or appropriate care for their athlete's with regard to SRC. Further research and development in the area of educational materials specific to lacrosse is a necessary step to providing the best education for lacrosse coaches and care for the health of lacrosse athletes.

CLINICAL RELEVANCE: Better educational materials on concussion for lacrosse coaches may narrow the gap between the current state of concussion knowledge and best practice and the functional knowledge that lacrosse coaches possess in those same domains. This will provide a safer environment for lacrosse players in the absence of event coverage by a trained medical professional.

KEYWORDS: Education, player safety, development

INTRODUCTION:

Sport related concussions (SRC) in both men's and women's lacrosse has been steadily increasing in conjunction with an 80% increase in participation for grades 6-12, making lacrosse one of the fastest growing sports in the United States. The rising number of diagnosed SRC indicates a growing reliance on trained healthcare professionals, coaches, parents and athletes to recognize and report symptoms. Many SRC go unreported or undiagnosed due to the lack of medical coverage and public knowledge regarding concussion symptoms and appropriate management protocols. In the U.S, 1.6-3.8 million SRC occur annually in high school and collegiate sports, with collision sports accounting for the vast majority of incidents.[1,2] In collision sports like football and lacrosse there is a 300% higher prevalence of SRC in men versus women, while there is a 200% higher prevalence for women versus men in sports that are comparable where men's and women's games are essentially the same.[1] The highest prevalence of concussion in high school sports are football (40.5%), women's soccer (21.5%), men's soccer (15.4%), and women's basketball (9.5%).[1] Football and men's lacrosse produce the majority of total SRC, accounting for a combined total of 1651 of 1986 concussions across all men's sports surveyed in McCrea et al[3] study from 1998-2008.

Concussion has become a hot topic for discussion among the medical community and public alike, specifically regarding treatment protocols and detection of concussion symptoms. Identifying concussion during practice or games is not always straight forward due to the broad spectrum of signs and symptoms and the timing of when they present in a concussed individual. The best precaution is to have a trained medical professional present at every athletic event to evaluate and determine if it is safe for the athlete to return to play. Unfortunately, this is not always the case as many middle and high schools do not have adequate medical coverage for

either practice or games. A recent study reported that only 70% of U.S. public high schools have athletic training services, with only 37% having full time athletic trainers.[4] Forty-seven percent of schools provide full practice coverage every practice while 30% had no athletic training services at all.[4] In many leagues where there is no medical coverage at all, acute injury and safety are left to the coaches and referees, even in the absence of appropriate training or level of understanding. Though medical coverage is increasing at all levels of sport, there are still a large number of SRC that go unreported either on purpose or as a function of inadequate medical coverage and knowledge of signs and symptoms by coaches, parents and players.[3,5,6,7,8]

In middle and high school (grades 6-12) club lacrosse, there is little coverage by medical personnel at games and almost none at all for practices.[4] In this scenario the burden of concussion recognition falls on the coaches, making education on recognition and management of concussion of the utmost importance. Coaches do not typically possess the appropriate medical education to effectively recognize and diagnose concussion, risking the player's health.[9,10,11,12,13] Resources are available for coaches but need to be examined for accuracy, depth and efficacy, as well as the method in which that information is presented. The literature shows that some educational materials are decidedly ineffective at promoting any positive changes in practice of preventing, recognizing and managing concussion.[9,10,15,16] The purpose of this study is to investigate the level of knowledge of SRC by high school lacrosse coaches and to understand current concussion education practices amongst this group. We investigated the coach's ability to recognize signs, symptoms and consequences of a poorly managed concussion, providing information to help build future educational resources for coaches. We hypothesized: 1) that coaches would demonstrate a poor knowledge of concussions and that they have received inadequate education or none at all; 2) that education would have a positive relationship on a

coach's ability to recognize symptoms and consequences of concussion; and 3) that formal education would provide better results than informal education.

METHODS:

This cross-sectional survey was approved by the University of Montana Institutional Review Board for the Protection of Human Subjects in Research. A single survey consisting of 16 closed ended questions was developed using existing literature and current research.[16] The signs and symptoms were sourced directly from the Center for Disease Control (CDC) "Heads UP" educational materials and the textbook, Principles of Athletic Training 15th Edition. [2,17,18,19] Cournoyer et al.[1] calculated a Cronbach's α for questions concerning concussion symptoms (α= 0.90) and consequences of concussions (α= 0.83) showing high reliability that these questions are appropriate to assess an individual's level of knowledge in these categories.[1] A self-administered, anonymous online survey was produced to collect data concerning middle and high school coach's knowledge of signs and symptoms of concussion, management, their comfort with discussing health concerns and management protocols for concussed individuals, grade level of team, years coaching, athlete gender, and previous education on concussion. Participants included active coaches of men's and women's lacrosse teams for grades 6-12 who are registered with US Lacrosse, the governing body of men's and women's lacrosse in the U.S.

The survey was distributed to the 13 chapter presidents comprising the Pacific and Mountain regions, requesting they distribute the survey to coaches in their chapter. Of 13, 2 chapter presidents agreed to distribute and post a link to the survey on their chapter website. For the remaining 11 chapters a list was populated from the chapter websites and emails were manually sent to each coach listed. Of the 785 emails sent, 530 did not reach their intended

target, leaving 255 potential participants. Of the 255 potential participants, we recorded data from 67 (26.2%) coaches across all 13 included chapters. Of the 67 participants 12% (n=8) coached middle school only, 76% (n=51) coaches high school only, and 12% (n=8) coached both middle and high school teams. Of these coaches 52% (n= 35) coached men's teams only, 43% (n=29) coached only women's teams, and 4.5% (n=3) coached both men's and women's teams.

STATISTICAL ANALYSIS:

There were 21 possible points with +1 point for every correct answer and -1 point for every distractor selected, while failure to select a correct answer resulted in 0 points. The sum of correct and incorrect answers provided the composite score. Data was collected and entered into Microsoft Excel for analysis. Descriptive statistics were used to determine the frequency and accuracy of symptoms identification and the consequences of concussion along with the percentage of participants that received formal or informal education and the format of the education received. An overall score was generated based on the percentage of correct answers and we assessed any overall association between composite score and education received with linear regression using IBM SPSS version 22.0. Cronbach α was calculated to assess reliability of signs and symptoms scale as well as the consequences scale.

RESULTS:

Symptom and Consequence Recognition

Among participants, an average composite score of 13 ± 3 (62%) for the total tabulated symptom and consequence sections was recorded. When calculating a Cronbach's α analysis to determine internal consistency of symptom and consequence selection separately we calculated

α= 0.734 for symptom identification and α= 0.631 for consequence identification. The α coefficient for symptoms recognition falls in accepted range and thus supports the internal reliability of data, while α coefficient for consequence recognition is just under this range, while still higher than what is considered unacceptable. This leads to questioning of the internal reliability of the data set regarding consequence recognition.[20] The highest score recorded was 18 (n=3, 85%) with 9 participants scoring ≤10 (≤45%), and an average of 2.4 distractors selected. Over 80% of coaches were able to correctly identify 9/14 symptoms, with the remaining 5 correct symptoms were correctly identified by less than 75% (Table 1). Only 2/7 correct consequences were correctly identified by ≥80% of participants, with ≤70% of participants correctly identifying the remaining 5 correct consequences, which represent some of the most severe and concerning consequences on the survey (Table 2). Most participants could identify symptoms like poor balance (99%) and nausea/vomiting (96%) but ≤65% identified sadness, neck pain, and ringing in ears, or excess sleep (Table 2).

Education Sources

Data regarding the source of educational material was collected with the intent to not only determine the most prevalent source, but also from what medium it was presented. Each participant was asked to select if they had received formal or informal education on concussion and to identify how the material was presented (Table 3, Figure 1-2). Participants that received formal education most frequently utilized online courses (56/63, 88.89%) while the most frequent informal education source was video (42/65, 64.62%) (Figure 1-2). A linear regression analysis yielded an r = 0.10 for formal education sources and an r = 0.14 for informal education sources indicating that we cannot use education source as an explanation of variability in the total score for the symptoms and consequence recognition sections of the survey. Our data is

consistent with a previous study that investigated the correlation between education source and ability to recognize concussion symptoms and consequences (R^2=0.032), determining a low correlation.[1]

We asked participants to answer what source they thought provided the highest quality of education and which sources they preferred (Figure 3-4). Participants identified online courses (41/65, 63.08%) and presentations by trained professionals (37/65, 56.92%) as their preferred source of education, while they identified the best method to learn as presentations by trained professionals (44/66, 66.67%) and classes that were either in person or by correspondence (42/66, 63.64%).

We asked our participants how many years they had been coaching, to investigate if there would be any correlation between years coached and composite score. We recorded 11% (n=7) had been coaching for 0-1 year, 34% (n=23) for both 2-5 years and 5-10 years, 12% (n=8) for 11-15 years, and 7.5% (n=5) for 20+ years of coaching experience. In line with the concept that education source had no significant effect on composite score we ran a linear regression analyzing the numbers of years coached against composite score (r=0.04) and found a low correlation.

Personal Perception of Knowledge

In the final section, a 5-point Likert scale was used for questions regarding the participant's perception of their own knowledge and willingness to act appropriately in the event one of their athletes sustains a concussion. Numbers 1-5 were assigned to each available response: Strongly disagree, somewhat agree, neither agree nor disagree, somewhat agree, strongly agree, respectfully. The median and mode calculations for each question indicate that in the context of these questions that participants scored well with what would be considered

correct by the investigators; however, this data only describes how each participant subjectively perceives their level of knowledge, and is not in line with the data collected that we are using to objectively to measure (Figure 5). Participants selected that they felt comfortable with their level knowledge of symptoms and consequences (48% selected somewhat agree) and also with talking to athletes/parents (51% strongly agreed), and teacher's/school administrators (66% strongly agreed). Participants also selected strongly disagree for questions concerning return to play if a potential concussion had occurred (100%) and if it was alright to return an athlete to play if he was exhibiting concussion symptoms but did not lose consciousness (96%).

DISCUSSION:

Sport related concussion (SRC) diagnosis is difficult with or without specific training, practice and understanding of the mechanisms involved due to the complexity of symptom presentation and the unique nature to each individual and each concussion. With 9 of 10 Americans being unable to even correctly define a concussion, there is a strong need to investigate how we approach education specifically with at risk populations.[21] Coaches across many sports are now required to take courses on concussion and sport safety in an effort to address the growing health concern centered around SRC. Our data, and the literature reviewed, suggests that there was no significant correlation between education, formal or informal, and ability to recognize concussion symptoms and consequences and rule out distractors. This can be interpreted as poor knowledge transfer (KT), and an inconsistency or insufficiency in standards of education resources.[11] While the current educational models do provide a base of information to build upon, further development of these materials tailored to specific sports and populations is necessary in order to increase the retention of this information for lacrosse coaches.

Symptom and Consequence Recognition

Participants scored an average of 13 of the total 21 (62%) possible points associated with symptoms and consequence recognition. To the investigators this is considered sub-optimal as many of the symptoms and consequences were not identified correctly by participants. While this number also is summative with the selecting of distractors, it indicates a poor level of knowledge by the participants. Only a handful of participants had high composite scores within what we would consider to be ideal (≥80%), further indicating that there is need to improve educational materials to help the coaches provide a safe field of play for athletes. This becomes especially important when considering that a trained medical professional such as an athletic trainer is not always present for practice or games.[4,22] Previous studies have shown that our participants are consistent with the average for coach's surveyed across other sports (62%) and so our results do support the concept that educational materials have the same knowledge transfer effect as in other sports.[11] Another study by Glang et al.[12] reported 70% accuracy for symptoms recognition and 64% for coach's general knowledge of concussion. Within the composite scores, we can also identify which symptoms or consequences were more frequently selected and which are not recognized by as many participants. A Harris-Poll out of UMPC supports our data and also reported specific symptoms that were more commonly overlooked. They found that while many of their participants could correctly identify the immediate signs and symptoms of concussion, other signs like vomiting (48%) sleepiness (40%) and mood changes (13%) were selected by less than 50% of their participants.[21] Some of the key identifying symptoms of concussion are frequently overlooked, doing on a survey is not an immediate problem. However, if those same symptoms are overlooked in a game or practice it becomes an immediate health risk.

While our data set indicates the need for improvement in education standards, we also can see that whether the participant had received formal or informal sources of educational materials had no bearing on ability of the participant to correctly identify symptoms or consequences. While we cannot conclude that it is solely inadequacies in the educational materials that are causing this lack of acceptable knowledge, having data that shows specific areas that are below standard is of great importance when developing educational models.

Personal Perception of Knowledge

In this section of the survey we asked the participants to rate where they believed their personal level of knowledge of concussion information and willingness to act falls on a 5 point Likert scale. Our data shows that coaches are comfortable with talking to parents, athletes, teachers and school administrators about concussions, and this is a positive step as a coach plays an invaluable role in advocating for their athlete's safety and well-being. However, their subjective analysis of their own level of knowledge is not a true indicator of their knowledge. Our participants displayed a gap between perception and reality for their level of knowledge with regard to concussion symptoms and consequences. According to a UPMC Harris-Poll, individuals that perceive themselves to have a greater knowledge about concussions do not tend to be any more intelligent about the basics of concussions.[21] Inflated perceptions of one's own knowledge can impede learning by removing the motivation to learn about any topic, a concept that is certainly applicable in this context.[23] Implementation of more frequent testing throughout a season may help to illuminate the areas that each coach needs further instruction on, provide feedback and time for reflection and could help to provide further direction for building educational models in the future. If coaches are able to see for themselves the gap between their

perceived mastery of a topic and their true level of understanding it could be a motivating factor and at the least a wake up call for those that possess sub-par knowledge.

Education and Looking to the Future

As new educational materials are developed, our data suggests that to target lacrosse coaches we should focus efforts on classes and presentations that provide a more comprehensive and immersive learning experience. Our data showed that this is how coaches prefer to learn and is also consistent with the education source they thought was best. Knowing demographic preferences is important, but there are other essential aspects to developing an educational model for adults that should not be overlooked. Mezirow wrote about the "critical theory to adult learning" and brings up several points that emphasize context, reflection and interaction as key components to adult education.[23] When developing educational materials for a specific demographic, like lacrosse coaches, it is important to fit the context of the information to the individual who is receiving it so that they can see it is applicable to them. Knowledge transfer principles utilize these same concepts and are used to develop knowledge creation and application methods involving exchanges and interactions between researchers that create and use the knowledge.[11] Use of models like KT are extremely important for future development of the most effective educational materials. The KT model provides the basis for the knowledge-to-action (KTA) framework that may help develop better educational materials. KTA involves two parts; knowledge creation, and action.[11] Knowledge creation is research based and involves refining, and tailoring to the needs of knowledge users and requires collaboration between the knowledge creators and users.[11] The action cycle involves the application of knowledge to achieve the desired changes in the focal group or population.[11] Use of KT models is one of the

ways that we can begin to develop and asses our concussion education materials and hone in on best way to impact concussion knowledge.

LIMITATIONS:

Limitations for this study include population size, expected knowledge outcomes, geographic differences in educational requirements, individual experience and self-reported limitations. Another limitation that was proposed was the design of this survey, which had the feel of a test, and could change the approach of participants while completing it. While the investigators believe that there was little to be done to change that aspect, it should be noted when looking at the data. In an effort to minimize these limitations the investigators took several steps focused on participant recruitment. We initially attempted to have all presidents of the selected chapters aid in distribution in the hopes that coaches would be more willing to participate if they were contacted by an administrator rather than the investigators themselves. To minimize the feeling that this was a test rather than a survey, we included a description of the study and what the data would be utilized for, emphasizing that collected data would have no personal identifying criteria to ensure anonymity of the participants.

CONCLUSION:

In conclusion, we have determined that middle and high school lacrosse coaches need to be better educated about concussions. There is a need for advancement in the educational materials provided to coaches to ensure we are giving them a high quality of information about concussions. This starts with tailoring educational materials to the sport and the demographics of the coaching community of that sport. There is certainly a need for further investigation into how

to present new material and ensure that it is not only disseminated through the coaching ranks but also that the information is being transferred into knowledge and practice. Through research into the best platform for education and efficacy of our current models, it is our belief that we can begin to close the gap between the current state of concussion knowledge and the level of knowledge that lacrosse coaches possess. While the best course of action is to have trained medical personnel on site for every practice, training session and game, though this is not an option for many. In light of that the reliance on coach's, parent's and athlete's ability to recognize a concussed individual and subsequently how to act on when a concussion is suspected or diagnosed is of the utmost importance to the safety and well-being of our athletes.

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Tables:

Table 1. Symptom identification

Symptoms	Coach %
Vacant stare	94% (n=63)
Drowsiness	93% (n=62)
Nausea/ Vomiting	96% (n=64)
Irritability	72% (n=48)
Neck pain	48% (n=32)
Inappropriate emotions	82% (n=55)
Excess sleep	64% (n=43)
Sensitivity to light	93% (n=62)
Sensitivity to noise	84% (n=56)
Feeling like they are in a "fog"	99% (n=66)
Poor balance/coordination	99% (n=66)
Fatigue	81% (n=54)
Sadness	42% (n=28)
Ringing in ears	60% (n=40)
Distractors	**Coach %**
Difficulty Breathing	22% (n=15)
Pale skin	25% (n=17)
Neck Spasm	16% (n=11)
Black eye	10% (n=7)
Epistaxis (bloody nose)	10% (n=7)

Table 2. Consequence Identification

Consequences	**Coach %**
Dementia	55% (n=37)
Persistent dizziness	80% (n=53)
Death	64% (n=43)
Persistent headache	87% (n=58)
Brain bleed	70% (n=47)
Alzheimer's Disease	54% (n=36)
Parkinson's disease	34% (n=23)
Distractors	**Coach %**
Stroke	40% (n=27)
Persistent neck pain	36% (n=24)
Blindness	31% (n=21)
Persistent jaw pain	30% (n=20)

Table 3. Demographic information

	Yes	No
Formal Education	63 (94%)	4 (6%)
Informal Education	64 (96%)	3 (4%)
Middle School	8 (12%)	
High School	51 (76%)	
MS +HS	8 (12%)	
Affiliated	46 (69%)	21 (31%)

Figures:

Figure 1. Formal education source selection.

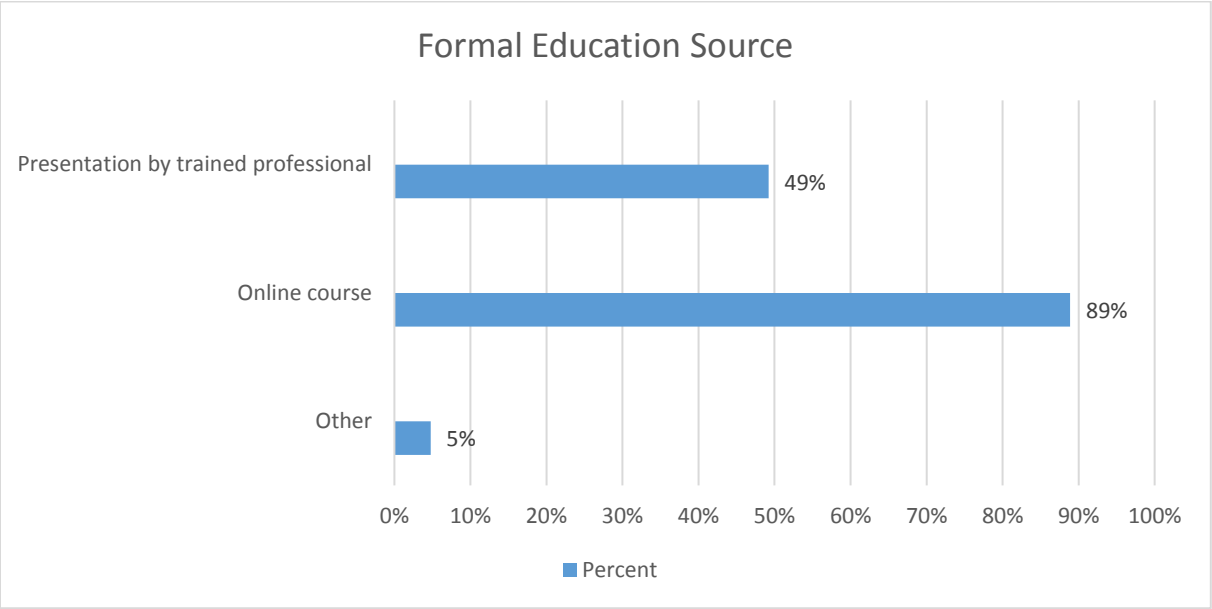

Figure 2. Informal education source selection

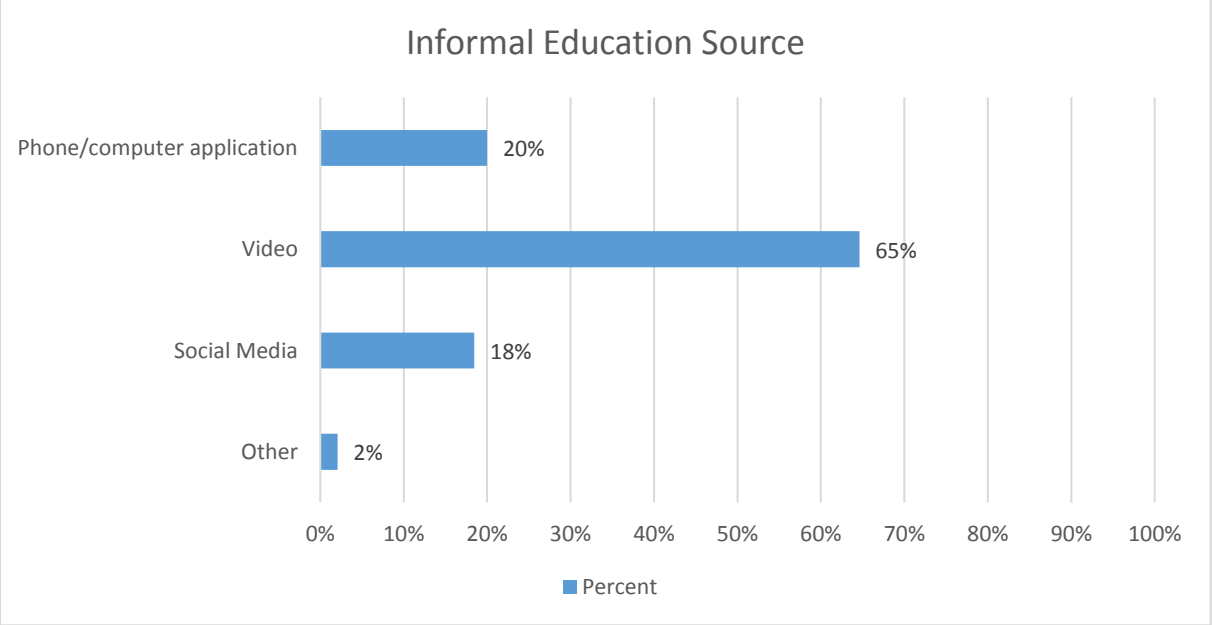

Figure 3. Preferred education source selection.

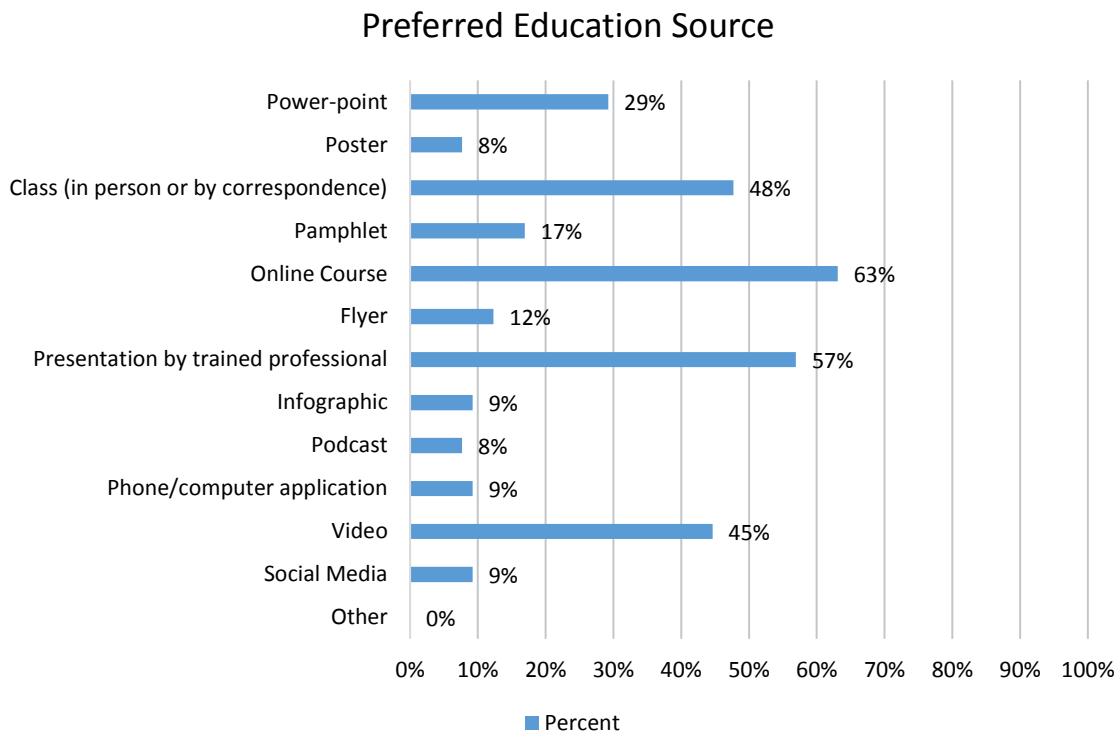

Figure 4. Coaches selection of best source of education

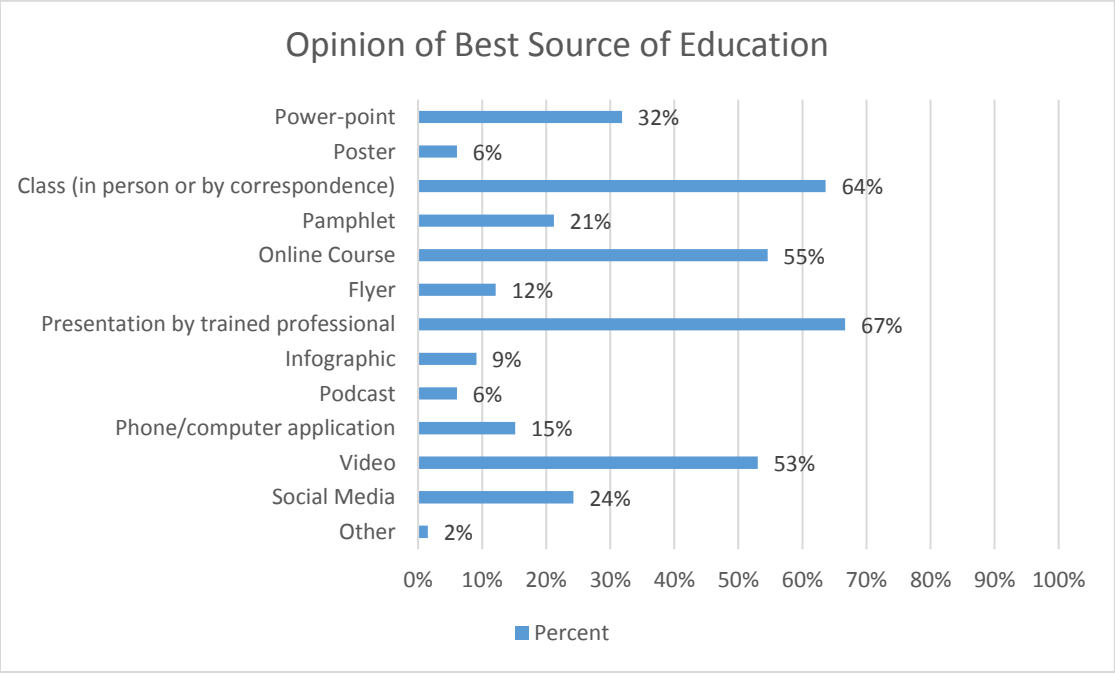

Fig. 5 Coaches perception of own knowledge