THE EFFECT OF PROTECTIVE EQUIPMENT AND MECHANISM OF INJURY ON TIME LOSS FROM SPORT-RELATED CONCUSSIONS

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DEDICATION

To my mother, Elizabeth Miclay, who is my best friend, my confidante, my role model, and the one person I can always count on. Even at my worst, you accept and love me for the person I am. I have always appreciated your unconditional support and I do not think I will ever be able to repay you for that. The strength you have shown me has helped me become the strong, fierce, resilient person I am today. There is no one I look up to more than you and I will spend the rest of my life doing everything I can to make you proud.

This thesis is for you.

I love you,

—Anya

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The success of this thesis wouldn't be possible without the support from all of my committee members.

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LIST OF ABBREVIATIONS

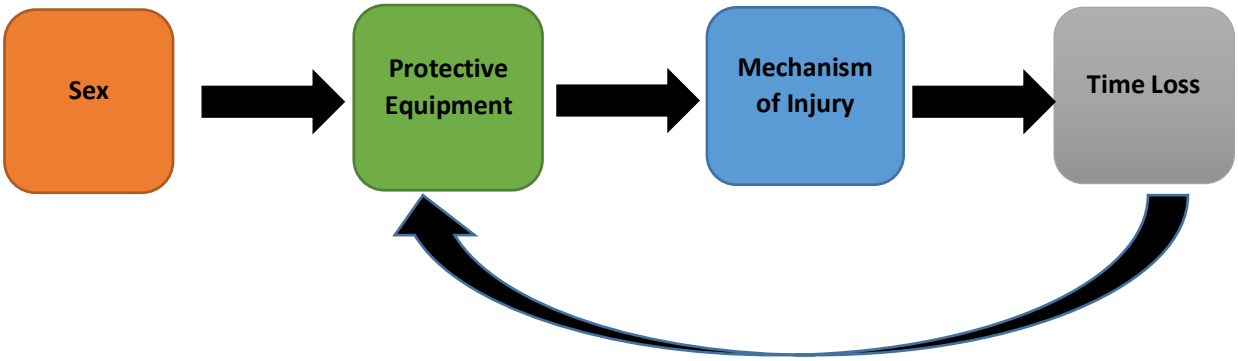
AE	Athlete exposure
AT	Athletic Trainer
DV	Dependent variable
IV	Independent variable
MOI	Mechanism of injury
NCAA	National Collegiate Athletic Association
OR	Odds Ratio
RR	Risk Ratio
RTL	Return to learn
RTP	Return to play
SRC	Sport-related concussion

1. INTRODUCTION

Annually, an estimated 1.6-3.8 million sport-related concussions (SRC) are sustained in the United States every year.[1] A concussion is direct or indirect contact to the head, face, neck, or body, which results either in a collision between the brain and skull or in a strain on neural tissue and vasculature.[2] The results of these temporary alterations in neurological and neurocognitive functioning typically resolve within 1-2 weeks post-injury in adults. Due to the commonness of SRCs across all types and levels of sport, research to determine the potential relationship between protective equipment and mechanism of injury (MOI) could be helpful in reducing SRC risk and the short- and long-term consequences. Understanding how these factors individually influence SRC risk could assist researchers and clinicians on the amount of SRC time loss. Figure 1.1 demonstrates how protective equipment and mechanism are influenced by sex. Sex, ultimately, determines which sports an individual will participate in and the sport will determine the amount of protective equipment worn. Athletes may alter their playing technique as a result of the protective equipment they are wearing. As a result, athletes who play sports that require more equipment may sustain concussions from different MOIs compared to athletes who play sports that require little-to-no protective equipment. The MOI present and the amount of protective equipment worn at the time of injury could also influence the amount of SRC time loss experienced by athletes. Furthermore, the amount of time loss experienced following a SRC could cause an athlete to alter the type of protective equipment worn or their technique following recovery. These protective equipment and technique (MOI) alterations could occur after each incident

SRC if the athlete attributes their SRC or the resultant time loss to their protective equipment and/or their MOI.

Figure 1.1. Theoretical progression from sex to time loss from SRC.



Recently, studies have started investigating the relationship between sex and SRC. Covassin et al. determined that females were 1.4 times more likely to sustain a SRC when compared to males.[3] These researchers also stated that females are more likely to report symptoms of a SRC, which may be a possible reason for this increase the number of reported SRCs in females. Females also have an increased blood flow[4] to the brain, neuroanatomical differences (i.e., greater number of unmyelinated axons),[5] and the presence of the hormone estrogen could all be contributing factors to the increased incidence of SRC among females. Like sex, protective equipment may be a contributing factor to SRC risk.

The relationship between protective equipment and SRC has not been well investigated, possibly because not all sports utilize protective equipment. There are many studies that investigate equipment in football,[6,7] soccer,[8] and ice hockey[9] and use this data to evaluate the likelihood of SRC within those sport. Protective equipment is not and cannot be designed to prevent SRCs. However, protective equipment type and amount worn may be related to SRC risk. Kerr et al. investigated the effectiveness of equipment

worn during collegiate football practices and concluded that individuals who wore full protective equipment were 22 times more likely to sustain a SRC compared to helmet only practices.[6] When practicing while wearing shells, compared to an individual in fully padded equipment, these individuals were 2 times more likely to sustain a SRC. The researchers concluded that less protective equipment may play a factor in the relative risk regarding SRCs. While the amount of protective equipment is an important factor to understand, MOI is also a factor to consider since the most common SRC MOIs may be dependent on sport and thus protective equipment.

MOI may be an important factor in predicting SRC risk and knowing what MOI is present could possibly indicate the amount of time loss associated with a SRC. SRCs occur in all sports and have been associated with multiple mechanisms, such as player-to-player contact,[10-15] player-to-surface contact,[10-12,14] player-to-object contact,[10-12,14] and indirect contact.[11] Currently, it is not known what the most common MOI is across all sports since many sports have not investigated to date. Because all sports have different rules and require various levels of protective equipment, it seems that the MOI is dependent on the sport. The most current study conducted by Fraser et al. investigated ball-contact related MOI for SRCs sustained in 11 National Collegiate Athletic Association (NCAA) sports and concluded that softball and baseball had the highest risk of sustaining a SRC compared to the other nine sports. When compared to football, softball was about 8 times more likely to sustain a SRC and baseball was 6 times more likely to sustain a SRC. The MOI in baseball and softball is different compared to other sports. The most common SRC MOI in both baseball and softball was being hit by the ball, which differs from player-to-player contact, which is the most common SRC MOI

for football players.[15] Unlike a football where player-to-player contact is deliberate, contact with the ball in baseball and softball is unintentional. Currently SRC-related MOI research is lacking. However, it is important that a more in-depth investigation across all sports be conducted to determine how MOI may affect SRC risk in all sports. Knowing the role that both MOI and protective equipment play could help researchers better understand the effects both could have on SRC risk.

SRC recovery can be complex due to the multiple individualized factors (signs and symptoms, physiology, concussion history, age) related to the person.[16] These factors may not only alter signs and symptoms at the time of injury, but can influence the amount of time loss from sport and academics during the recovery process.[3] Many researchers have investigated time loss related to SRC in regard to MOI[12-14] or protective equipment[6,7,17] in isolation. However, information is currently lacking concerning the associations between protective equipment, MOI, and time lost after SRC.[18]

1.1. Statement of Problem

Currently, research is lacking investigating the associations between protective equipment, MOI, and time loss from SRC. Since MOI and protective equipment are present at the same time, there should be more research that investigates both risk factors associated with a SRC. As mentioned above, SRC risk for football players during practices with full protective equipment is 22 times greater than helmeted only practices.[6] Football, ice hockey, and soccer have been the primary focus for researchers interested in the relationship between MOI and SRC due to their elevated SRC rates compared to other sports.[8,18] The most current study published by Fraser et al. investigated the relationship between ball-related MOI, protective equipment, and SRC in 11 collegiate sports.[18] As

mentioned above, softball and baseball were more likely to sustain a SRC when compared other collegiate sports. The most common SRC MOIs in these sports were getting hit by a pitch or getting hit by a line drive. Softball and baseball players do wear helmets when hitting (hit by pitch), but the material is less substantial than a football helmet, but only have gloves for protection in the field (line drive). This lack of protective equipment was suggested by the authors as a reason for their increased SRC risk compared to football. There may be a correlation between protective equipment and MOI due the study design. The study investigated ball-contact injuries, which are less common in football compared to sports such as baseball or softball.[18] This study is one of the few that have included multiple sports and investigated protective equipment, MOI, and SRC. Fraser et al. also reported the amount of time loss for all 11 sports and determined that 51 percent of all injuries results in less than 1 day of time loss from injury. While less than 1 day may not be considered an injury by some, the criteria of the study stated that if a participant missed any sport participation, it would be considered an injury. Overall, women's soccer had the highest percentage of time loss when sustaining an SRC. Further research is necessary to determine how SRC-related time loss is associated with additional sports (with and without protective equipment) and a wider range MOIs.

1.2. Research Variables

1.2.1. Independent Variables

1. Protective equipment: a device worn by an athlete to reduce or eliminate injury. (See Table 1.1)

a. Optional: Any protective device that is not mandatory for sport participation (i.e., softball fielder's mask, women's lacrosse helmet).
b. Required protective equipment: Any protective device that's mandatory to participate in the sport (i.e., shoulder pads, helmets, gloves).
    i. High: Any sport that requires a significant amount of protective equipment to participate. Example would be shoulder and/or chest protectors and a helmet that is secured to the head with a strap or contains a full-face shield/mask (i.e., football, ice hockey, men's lacrosse, goalies, and catchers).
    ii. Low: Any sport that requires minimal amount of protective equipment to participate. Examples would be goggles, gloves (padded and unpadded), shin guards, a helmet that is not secured by a strap and does not contain a full-face shield/mask (e.g., softball/baseball hitters), non-helmeted facemask (e.g., softball infielders), head gear (wrestling)
    iii. No: Any sport where protective devices are not required or commonly worn during sport participation (i.e., swimming, track and field, cross country, etc.).

Table 1.1 Required and Optional Protective Equipment for Sport Participation

	Required/Optional Protective Equipment									
Sport	Helmet	Facemask	Eye protection (Goggles)	Throat Guard	Shoulder Pads	Chest/Abdominal Padding	Leg Pads	Gloves	Mouth Guard	Stick/Bat
Football	A	A			A		A	A[a]	A	
Field Hockey	G	G	A	G[a]	G	G	G	G	A	A
Volleyball										
Baseball	C/O	C		C[a]		C	O[a]/C	O[a]/D		O
Softball	C/O	O[a]/C		C[a]		C	C	O[a]/D		O
Women's Basketball									A[a]	
Men's Basketball									A[a]	
Men's Lacrosse	A	A		G[a]	A	G	G	A	A	A
Women's Lacrosse	G	G	A	G[a]	G	G	G	A[a]/G	A	A
Men's Soccer							A	G		
Women's Soccer							A	G		

Abbreviations: A, all athletes; C, catchers; D, defensive players (specific to baseball and softball, includes catchers); G, goalies only; O, offensive players (specific to softball and baseball).

[a] Optional protective devices that are often worn for the specified group.

2. Mechanism of injury (MOI): the manner in which the student-athlete sustained the injury.[18]
    a. Player-to-player contact: when an individual comes into physical contact with any body part of a teammate or opponent. (i.e., head, elbow, shoulder, knee)
    b. Player-to-surface: when an individual comes into contact with the playing surface (i.e., turf, wood, mat, concrete).
    c. Player-to-object contact: when an individual comes into contact with an inanimate object (i.e., soccer goal, field goal, table).
    d. Player-to-implement contact: when an individual comes into contact with a playing implement (i.e., ball, bat, puck).
    e. Indirect contact: a force or impact that sets the head in motion without directly striking it (i.e., a body blow resulting in whiplash).[19]
    f. Player-to-animal contact: when an individual comes in contact with an animal (i.e. horse or bull)

1.2.2. Dependent Variable

1. Time loss: Amount of time between initial injury and return to full athletic and academic participation.

Table 1.2 Independent and Dependent Variables

Independent Variable	Dependent Variable
Mechanism of injury (MOI) (Categorical)	SRC-related time loss (Ordinal)
Protective equipment (Categorical)	

1.3. Research Questions

Research Question 1: What is the association between protective equipment and SRC-related time loss?

Hypothesis 1: There will be a positive association between high levels of protective equipment and time loss following a SRC.

Research Question 2: What is the association between mechanism of injury (MOI) and SRC-related time loss?

Hypothesis 2: There will be a positive association between player-to-player contact and time loss following a SRC.

1.4. Operational Definitions

Sport-related concussion (SRC): A traumatic brain injury induced by biomechanical forces as a result of a direct or indirect contact to the head, face, neck, or body, which results either in a collision between the brain and skull or in a strain on neural tissue and vasculature.[2] The results of these temporary alterations in neurological and neurocognitive functioning typically resolve within 1-2 weeks post injury in adults. For the purposes of this study, all reported SRCs must have occurred during an organized practice or competition in high school or college.

Return-to-play (RTP): The length of time required to return to full athletic participation from a SRC.[20] These individuals must be asymptomatic at the start of the RTP protocol and prior to full return to sport. Medical clearance by a physician is required in most states before student-athletes are allowed to RTP.

1. Reported: Individuals with a reported SRC are instructed to complete a five-day RTP once the student-athlete is asymptomatic.
2. Unreported: Individual does not report SRC symptoms and continues to participate in his or her sport.

Return-to-learn (RTL): A general process for students requiring cognitive rest and require academic accommodations, such as reduced workload or extended time on tests, while recovering from a SRC.[21] These individuals may still be experiencing symptoms during this process. A student is fully returned to learn when no accommodations are needed to complete the required academic load.

1.5. Assumptions

1. The participants will provide accurate and truthful and accurate information about the protective equipment worn, MOI, and the amount of time lost for all reported SRCs.
2. The participants enrolled in this study and their SRC experiences were representative of all NCAA student-athletes in their respective sports.
3. Athletic trainers from all enrolled schools will distribute our survey (paper or Internet-based) to all athletes under their care with a SRC history.

1.6. Delimitations

1. All participants will be current NCAA student-athletes or cheerleaders.

1.7. Limitations

1. Some schools may have a better relationship with the research team, or greater interest in concussion research, which may alter participation across schools.
2. Memory recall may be affected if a significant amount of time has passed between the time of injury and participation in the study.

1.8. Significance of the Proposed Study

Multiple studies have indicated that more protective equipment and MOI type are associated with an increase in concussion rates in athletes.[6,22] Unfortunately, these concussion factors have not been investigated concurrently across all sports, nor has research determined their relationship to time loss after SRC in all sports. This information is important in improving sport safety, thus reducing concussion risk. These findings will allow healthcare professionals, coaches, athletes, and governing bodies to improve rules concerning protective equipment and MOI to reduce SRC risk and time loss after injury, thus improving the well-being of current and future athletes.

2. LITERATURE REVIEW

A concussion can result from direct or indirect contact to the head, face, neck, or body, which results either in a collision between the brain and skull or in a strain on neural tissue and vasculature.[2] The results of these temporary alterations in neurological and neurocognitive functioning typically resolve within 1-2 weeks post-injury in adults. A sport-related concussion (SRC) is a concussion sustained during an organized athletic practice or competition. It is estimated that 1.6 to 3.8 million sport and recreational related concussions occur in the United States every year.[1] Compared to other high school and collegiate sports, participants in soccer, rugby, football, ice hockey, and men's wrestling have the highest incidence of diagnosed SRC.[6,23] It is important to identify factors that may increase SRC risk and what can be done to mitigate SRC time loss from school and academics in the athletic population.

Sex has been determined to be an important consideration in SRC research. Typically, females will report more SRC-like symptoms compared to males.[3] This could be contributed by an increase in blood flow[4] to the brain, neuroanatomical differences (i.e., greater number of unmyelinated axons)[5], and the presence of estrogen in females. This data could demonstrate that females are more at risk of sustaining SRC and lose more time from their sports.[3] Understanding what other metrics may alter the associations among sex, SRC incidence, and time loss from SRCs, including protective equipment and mechanism of injury (MOI) would help further improve sport safety and injury risk and outcomes.

Protective equipment is worn in many sports (i.e., football, ice hockey, baseball) to reduce injury risk, including SRC, but not all sports (i.e., soccer, basketball, cheer,

track) wear similar protective equipment. The majority of research investigating SRC and protective equipment has been in ice hockey,[9] football,[6,7] and soccer,[8,24,25] but is lacking in other sports, both male and female. Most of the current research states that less protective equipment could be beneficial in reducing the incidence of SRC, but this variable may be sport dependent as well. Currently little is known about the relationships between SRC incidence, protective equipment, MOI and time loss across all sport types.

MOI is the manner in which the student-athlete sustained an injury and it is important to understand in injury/SRC research. Understanding where the SRC risk regarding MOI is could lead to an increase in knowledge for both researchers and clinicians. SRCs can occur in all sports as a result of multiple mechanisms, such as player-to-player contact,[10-15] player-to-surface contact,[10-12,14] player-to-object contact,[10-12,14] and indirect contact[11]. Athlete-to-animal contact may occur between student-athletes and their horse during equestrian-related activities. Unfortunately, to date there have been no studies investigating MOI for SRC in either equestrian or rodeo. Therefore, there is no standard definition for an athlete coming in contact with their horse. However, for the purposes of this study it will be defined as a student-athlete sustaining an SRC as a result from direct or indirect contact with their horse. Indirect contact is defined as a force or impact that sets the head in motion without directly striking it (e.g., a body blow resulting in whiplash).[19] Fraser et al. found MOI was associated with both injury type, protective equipment worn by the athletes, and time loss. Unfortunately, their study focused on ball-related injuries and cannot be generalized to all MOIs, or sports that do not use a ball.

Multiple studies have investigated head impact biomechanics and time loss,[3,26,27] but few studies have considered the effects of protective equipment and MOI on SRC-

related time loss. The purpose of this literature review is to investigate the following topics and their relationship with SRC: (a) sex, (b) protective equipment worn at time of injury, (c) MOI, and (d) time lost from both academic and athletic participation.

2.1 Sex

SRC affects males and females differently. Kerr et al. investigated the number of all soccer-related injuries that were treated in United States emergency departments from 2004-2013.[28] Of the 63,258 soccer-related injuries, SRC accounted for 2,981 (4.7%) of injuries. Females also had a higher proportion of overall SRCs (5.2%) compared to males (3.5%). This demonstrate that females may be at an increased risk of sustaining a SRC. Overall, males were evaluated more often in emergency rooms compared to females. It is important to note that most SRCs do not require emergency room care. Because of this, these data represent an inaccurate number of the SRCs that occur annually from soccer. It could be argued that the style of play in men's soccer is faster and more violent than women's soccer, which could explain why there were more males evaluated in emergency rooms.

In another study evaluating SRC rates across multiple sports, Zuckerman et at. concluded that women's soccer had a higher overall SRC rate (RR=1.83) compared to males.[29] A risk ratio is the probability of the outcome (sustaining a SRC) between an exposed group (exposed to MOI/protective equipment) and the unexposed group (not exposed to MOI/protective equipment) The SRC rate was also higher for women's in competitions compared to males in competitions (RR=2.00). There was no difference

between males and females in SRC rate for practices (RR=1.22). This helps confirm that females are more likely to sustain an SRC compared to males.

Females will typically experience SRC symptoms for a longer duration, which results in more time loss when compared to males.[3] On average, males lose 7-10 days of participation, whereas females lose 10-14 days of participation. There are many possible factors that could explain the SRC risk between males and females. Decreased reaction time is one factor that leaves females predisposed and could lead to an increase in time loss from SRC.[30] A decrease in reaction time could result in a more severe injury and could increase the recovery time.

Conversely, other study findings have suggested that females are more likely to suffer from post SRC symptoms. A study investigating the relationship between sex and post-concussive symptoms found that active adult females (mean age of 37) were more prone to suffering from post-concussive symptoms three months after sustaining a mild SRC compared to active males (mean age of 30).[31] The same study was conducted with minor females (mean age of 13) and the results were not significant compared to the adult females in the study. This helps support our study by demonstrating that sex is a driving force in concussion research but should not be the only factor that is investigated.

2.2 The Role of Protective Equipment

Unlike sex, protective equipment has not been investigated as frequently as a possible factor for increased SRC risk. Football has a few research studies regarding protective equipment,[6,7] but research is still lacking in this area.[17] Due to the lack of research, researchers are unsure if protective equipment has any effect on time loss from

a SRC. The research that has been conducted suggests that less protective equipment in football may be beneficial in reducing the incidence of SRC.

In 2011, Virginia Technological University developed The Summation of Tests for the Analysis of Risk (STAR) evaluation system. This evaluation system is used to determine the effectiveness in the reduction of SRC risks and helmets are given a rating of 0-5 stars, where 5 is the highest rating.[32] Even though this rating system is used to improve the quality of football helmets, it does not guarantee a reduction in SRCs since no helmet is concussion-proof. A helmet cannot stop the brain from coming in contact with the skull, thus no helmet can be considered concussion-proof.

Typically, researchers have reported an increase in injuries, including SRCs, when an individual is wearing more protective equipment.[7,18] Kerr et al., used the National Collegiate Athletic Association Injury Surveillance System (NCAA ISS) of 60 NCAA football programs (28 DI, 10 DII, 22 DIII; 9.7% of all universities sponsoring football) and investigated the incidence of SRC in practices (walk-throughs, scrimmages, and regular).[6] From 2004-2005 to 2008-2009 a total of 1367 SRCs were reported in their study with 795 (58.2%) SRCs occurring during practices.[6] During this five-year prospective study, it was determined that there was an increased incidence of SRC while players were wearing full protective equipment.[6] Full protective equipment consists of a helmet, shoulder pads, and pelvis and thigh pads.

Overall, the SRCs per athlete exposure (AE) for practices overall was 0.39/1000, with 0.66/1000 AE, 0.33/1000 AE and 0.03/1000 AE occurring during full protective equipment, only shells (shoulder pads and helmets), and helmet only practices respectively. An AE is defined as one student-athlete participating in one NCAA-

sanctioned practice or competition in which he or she was exposed to the possibility of athletic injury, regardless of time associated with that participation.[6] The number of SRCs was greatly reduced as more protective equipment was removed.[6] Researchers also reported that when the participants were only wearing shells 184 (25.8%) SRCs occurred during practices compared to three (3.7%) SRCs from scrimmages and none during walk-throughs.[6] Researchers may have gotten these result due to the increase number of AEs that occur during practice, therefore, the risk of sustaining a SRC is greater during practice compared to competitions. Researchers concluded that protective equipment, in particular football helmets, can give athletes a false sense of security.[6]

Fraser et al. investigated the injury rates of 11 collegiate sports that use a ball.[18] Interestingly, their data suggested that there was an increased SRC rate in sports with little to no protective equipment, like softball and baseball compared to those with significant protective equipment requirements (football). When evaluating the rate of injury between the three sports, softball was 8 time more likely to sustain a ball-contact injury and baseball was about 7 times more likely to sustain a ball-contact injury when compared to the injuries sustained in football.[18] In baseball and softball, there were 187 ball-contacts (softball) and 163 ball-contacts (baseball) that resulted in general orthopedic injuries with an overall injury rate of 7.20/1000 and 8.82/10,000 AE respectively.[18] In football, there were only 86 ball contacts which resulted in 0.77/1000 AE. The AE is considerably lower for an individual participating in football. While investigating general orthopedic injuries, Fraser et al. reported that the SRC risk was lower in football with 1.2% (n=1) of injuries occurring from SRCs. Whereas softball had 17.1% (n=32) of injuries occurring from SRCs and baseball was lower with 6.1% (n=10) of injuries

coming from SRCs.[18] When comparing football to other sports, such as softball and baseball, it should be taken into account that there are differences in how the game is played. Fraser et al. concluded that softball and baseball sustain more injuries compared to other sports due to the shape of the ball and the amount of equipment worn could have influenced the differences observed between sports.

Another study conducted by Barbic et al. investigated the effectiveness of mouthguards in reducing SRC incidence over the course of a collegiate competiton season.[33] Researchers recruited four football, male rugby, and female rugby teams (n=614). All of the sports were separated into intervention (mean age of 20.9) and control groups (mean age of 20.8) with 2 teams being assigned to each group. The participants in the intervention group were given a Brain-Pad mouthguard and the control group was given a generic boil and bite mouth guard. Data were collected to determined the number of SRCs that occurred over the course of one season. During this time 43 SRCs were reported to researchers, representing 7% of the participants. This is below the average pre-season SRC incidence of 10-25% incidence reported.[33] The research team did not find a significant relationship between mouthguards and SRC rate (P=0.79).[33] The lack of significant findings is not surprising due to the original purpose of a mouthguard. A mouthguard's purpose is to prevent dental fractures not SRCs.

Headgear, in soccer, was a protective device worn since it was believed to reduce the risk of sustaining a SRC. But research is lacking in this area to confirm if the headband would be effective in the reduction of SRC incidence in soccer. Various styles of headgear have been produced with such styles as the Header, the Headblast, and the Protector headbands.[34] The Header consists of a closed-cell foam laminated to the outside

material of the headband. The Headblast has a flexible piece of plastic attached to a thin neoprene headband. The Protector consists of a hard plastic insert covered with foam and then fitted into a terry-cloth headband. A study conducted by Broglio, et al. evaluated the effectiveness of the different styles of headbands described above.[34] Soccer balls, traveling an average of 35 mph from a machine, were headed by the participants. Their study demonstrated that peak velocity of forces sustained to a subject's head decreased by 12.5% when wearing any of the headbands compared to the control (no headband). Broglio, et al. state that proper heading technique is still the greatest defense against injury. Delaney, et al. investigated the effectiveness of commercially available headbands that were being worn by female Canadian club soccer players age 12-17 years-old regarding head and face injuries.[8] Researchers concluded that the headgear reduced lacerations, abrasions, and contusions sustained from heading the ball on the front, side, back and top of head.[8] The headgear did not prevent lacerations, abrasions, and contusions from occuring to the face nor did it effectively reduce the risk of sustaining a concussion.[8] Withnall et al. evaluated the effectiveness of headgear and came to a similar conclusion that headgear did not reduce SRC risk.[35] These studies show that protective equipment is not associated with reduced SRC risk.

SRC research regarding ice hockey and protective equipment is lacking. There are few studies that investigate the effectiveness of a facemask/visor, and the research evaluating the helmet's effectiveness to reduce the prevalence of SRC is limited. There are many factors that should be considered as to why research in ice hockey is lacking. Even though the equipment worn is the same across men's and women's ice hockey, the sport itself is not played the same. The rules are significantly different, but many

researchers treat them as if they were equal. Unlike football, there are very few regulations on the recertification/reconditioning of ice hockey protective equipment. For instance football helmets must to be reconditioned yearly due to the increased number of head-to-head contacts that occur thorughout a season. Ice hockey helmets do not have to be reconditioned yearly and it is unclear if this would have an impact on SRC incidence in ice hockey. The Head Impact Telemetry System (HITS) is a head impact biomechanics tool available to collect impact data for ice hockey, but may only be compatible with certain helmets.

The increased injury rate at the professional level can be associated with the use of equipment that is worn and the level of skill required to carry out the task (i.e. ice hockey, football, and soccer).[36] The Peltzman effect theorizes that individuals change their behavior based on the perceived level of risk. Due to the Peltzman effect present in athletics, the preceived amount of risk an athlete is willing to accept directly correlates with the amount of equipment that is worn.[36] This supports and gives further evidence to previous studies that found more protective equipment is associated with an increase in SRC risk that may be a result of the athletes feeling more protected and thus be willing to take greater risks.

2.3 Mechanism of Injury

Mechanism is a very important aspect of a SRC evaluation. A mechanism of injury (MOI) is defined as the manner in which the student-athlete sustains an injury.[18] A traumatic event can result from MOIs including, player-to-player contact, player-to-surface contact, or indirect contact. Sports such as football, ice hockey, cheerleading,

wrestling, and soccer have multiple mechanisms and all these sports involve player-to-player contact, which has been associated with an increased prevalence of SRC. For instance, in collegiate football the concussion rates for practices and games were 3.74 and 0.53 per 1000 AE, respectively.[37] There are many factors that could explain why SRC rate are higher during practices when compared to competitions. The number of AEs are typically higher since every person on a team may participate in practice, but not everyone participates in competitions. The increased in AEs directly increased the changes of sustaining a SRC. Mechanism is more commonly researched compared to protective equipment, but there is still research lacking across all sports and not just ice hockey, soccer, and football.

Soccer is another sport that has a high SRC incidence rate and since it has the same rules and equipment this allows for equal comparison of MOI, equipment and SRC incidence between the sexes. The data from a 15-year NCAA women's soccer study (1988-1989 through 2002-2003) indicated player-to-player contact during games and practices resulted in 54% of all general orthopedic injuries, whereas player-to-surface contact and indirect contact each resulted in 22% of all injuries.[10] Overall, 10.8% of all reported injuries were SRCs, with athletes sustaining 463 SRCs during competitions (1.42/1,000 AE) and 130 during practices (0.12/1,000 AE). These data indicate that SRC risk is greater in competitions than practices because individuals will assume more risky behavior in competition compared to practice. Female soccer athletes at the collegiate level are 1.4 times more likely to sustain a SRC than males.[3] When comparing MOI, men's and women's soccer are very similar. Both sports experience concussive injuries as a result of player-to-player contact.[38] This data demonstrates that when certain MOIs

are present, women are at an increased risk of SRCs. More research should be conducted to determine if the relationship between sex-related concussion risk and MOI is present across all sports.

When investigating SRC incidences there are certain sports that have a higher SRC rate. In a study conducted by Kerr et al, it was determined that men's wrestling had the highest incidence of concussions across all sports. The SRC incidence in men's wrestling (0.89/1000 AEs) was higher than women's ice hockey (0.78/1000 AEs), football (0.75/1000 AEs), and men's ice hockey (0.74/1000 AEs).[23] While incidence rate was higher in men's wrestling, but football did have the largest average of SRCs per team. Football also had the largest percentage of teams with at least 1 concussion sustained prior to the start of the study. The rate at which athlete's sustain SRCs overall, in particular, and via certain MOIs is important to understand since this will inform clinicians and researchers about who is at greatest risk and when. This information could then assist administrators, coaches, and clinicians on best practices for prevention through protective equipment and sport rule changes. If researchers understand what sports are at an increased risk of sustaining a SRC, it could improve the care provided by healthcare professionals. With exception to the Kerr et al study, there are very few studies investigating the concussion incidence among different sports (men's wrestling, softball, baseball, etc.).

Unlike soccer, ice hockey is not a sex-comparable sport due to rule differences. This means researchers could compare results in ice hockey, but may have a difficult time comparing those results due to the differences in play. Even though the protective equipment is identical, the difference in rules (between men's and women's) change the

MOI associated with the sport. This could change the SRC rate associated with ice hockey. The most common three SRC MOIs in men's ice hockey, at the collegiate level, are contact with another player (50%), contact with boards or glass (31%), and contact with the ice (7%). The three most common SRC MOIs in collegiate women's ice hockey are contact with another player (50%), contact with boards and glass (17%), and indirect contact (15%).[11] Researchers concluded that, with exception of player-to-player contact, mechanisms in women's ice hockey are distributed more evenly when compared to the mechanisms that occur in men's.

At the University of Minnesota, a 7-year study was performed to observe the injuries sustained between the men's and women's National Collegiate Athletic Association (NCAA) ice hockey teams.[39] Over the course of the study, researchers concluded that women (0.82/1000 AE) had a higher rate of SRCs compared to men (0.72/1000 AE).[39] Player-to-player contact was responsible for 41% of SRCs in women, but 82% of SRCs in men.[39] Overall, women in ice hockey can have different mechanisms (indirect contact, player-to-surface contact, player-to-player contact) compared to men but still have a higher incidence of SRCs. The mechanisms will be different since the style of play is different and men tend to be stronger and more willing to engage in risky behavior. This study helps support our study, but further research should investigate the effectiveness of MOI and equipment together and separately.

2.4 Time Lost from Sport-Related Concussions

Researchers investigating the relationships between protective equipment, MOI, and the length of time an athlete is removed from participation after sustaining a SRC is

lacking. Typically, women require more time to recover from SRCs compared to men.[40] On average, women, at the high school and collegiate levels, miss 14 days of activity compared to 10 days of activity for men.[40] Dick et al. reported there was no significant difference in the amount of time loss from athletic participation when comparing different age groups.[40]

Time lost from SRCs can be difficult to evaluate due to many factors such as differences in protective equipment and MOI when comparing different sports. Researchers also investigated time lost from SRC at the major league level for baseball. Wasserman et al. noted that players missed between 2 and 35 days of full athletic participation after a SRC (range 5 to 15 days).[41] Returning to play can be dependent on the MOI that occurred and should be taken into account how much time loss an individual could experience. There are many factors that could result in time loss and should be investigated further to determine if MOI and protective equipment contribute to the increase in time loss.

2.5 Summary

In conclusion, current research is lacking on how protective equipment and MOI are associated with time lost after SRC across all sports. All sports require different protective equipment and have different MOIs which could make data collection more challenging for researchers. Due to this difficulty, most researcher focus on one sports' protective equipment or MOI. Due to these deficits in knowledge, additional research should be conducted to determine how protective equipment and MOI are associated with time lost due to SRC.

The goal of this study is to investigate the amount of time loss from SRC and determine if protective equipment and MOI may play a factor. This study will be important because it will be one of the first studies that will investigate the relationships between these important SRC factors, which could help future researchers investigate protective equipment and MOI differently. This study will also be important because it could inform clinicians where the risks are of sustaining a SRC. This study will educate clinicians that care for all different athletes and not just one specific group.

3. METHODOLOGY

All participants enrolled were asked to complete a survey that collected demographic and concussion history information. Specifically, the participants were asked questions about the sport, mechanism of injury (MOI), the protective equipment worn in their most recent 5 SRCs, and the amount of time loss from each SRC sustained. A pilot study was conducted prior to data collect to ensure validity of survey questions. Participants in the pilot study were former student-athletes (N=10) who had no athletic eligibility left to participate. The research team distributed the internet survey for each participant to complete. After the survey was complete, the research team would interview the participant and ask if there was any confusion regarding the questions. Some questions had to be changed slightly to produce a more desired answer from future participants. See Table 3.1 for the Project Timeline.

Table 3.1 Project Timeline

	June 2018- June 2019						
Task	June-July	Aug	Sept-Oct	Nov	Dec-Jan	Feb-May	June-July
Pilot Study							
IRB Submission and Approval							
Subject Recruitment							
Data Collection							
Data Analysis							
Abstract (A) & Manuscript (M) Preparation						3MT	M and A

3.1. Recruitment

3.1.1. Participant Recruitment

The researchers contacted at least one athletic trainer (AT) from each institution about participating in our study. The research team contacted a total of 1,084 potential schools. All of the participants were given details of the study and gave consent to participate. The research team personally contacted the head athletic trainers (AT) at

collegiate institutions, through email, asking for their assistance in recruiting their student-athletes to be participants in this retrospective concussion study. The student-athletes were recruited and enrolled into this study via two mechanisms. Potential participants either received an invitation email (Qualtrics.com link) that contained a description of the study and a link to the survey, or a paper version (Appendix 1, 2) of which the email description was attached to the top of the survey. The paper surveys were distributed by their respective athletic trainer (AT). All participants were consented via their chosen survey method. The ATs at each participating school were allowed to determine the most effective mechanism for their school. The ATs had the option to give the paper version to some student-athletes and the Internet-based version to other student-athletes. Once consent forms had been signed, participants completed the survey (online or paper version) which asked a variety of questions about their five most recent SRCs.

3.2. Participants

Researchers contacted 1,084 NCAA schools by using the email address of the head AT listed on the institution's athletic website. A total of 20 schools expressed interest in participating. It is estimated that a total of 15 schools actually participated in this study. It is not possible to determine the actual number of schools since the survey did not collect that information. It is also difficult to determine how many schools participated because the student-athletes were not required to use their school emails. A total of 78 participants attempted the survey, but only 54 participants were enrolled in the study. Due to insufficient data, out of the 78 attempted surveys 24 participants were excluded from the analyses.

3.2.1 Inclusion and Exclusion

Participants were included if they were between 18-35 years old, on a current NCAA roster, and had a history of SRCs that occurred during organized high school or collegiate sport participation. Sport participation includes both school sponsored events as well as club sport events. The participants were asked to consider the following questions to determine if their concussion occurred during organized sport participation: 1) Did the team have organized practices, 2) Did the team have a competition schedule, 3) Did the team have a coach, and 4) Did the team have a roster for the season. Participants were excluded by the following criteria: 1) not fluent in English, 2) visual impairments that could not be rectified with corrective lenses. The survey was not available in other formats to accommodate participants with visual impairments.

3.3. Survey

The purpose of the survey was to gather demographic, SRC history and related-time loss, sport, MOI, and protective equipment information. The demographic questions inquired about the participant's sex, age, nationality, and regional location of school. The participants were also asked about the MOIs (i.e., person-to-person, person-to-surface contact, and player-to-implement, etc.) and protective equipment (i.e., helmet, full face shield, eyes only shield, goggles, gloves, shoulder pads, etc.), and sport-related time loss associated with their most recent five concussions.

All participants were asked to note the sport in which they were currently participating in at the beginning of the survey. The research team also decided to categorize protective equipment into high, low, and no based on the sport that was

indicated for each SRC. High levels of protective equipment would be any sport that is required to wear a significant amount of equipment to participate since the sport requires the participant to wear shoulder pads, helmet, facemask, etc. Sports such as men's lacrosse, football, ice hockey, along with catchers and goalies would be included in the high equipment group. Low would be any sport that required minimal protective equipment to participate and sports such as women's lacrosse, baseball, and softball would be included in this group. Any sport in the no equipment category would not be required to any protective equipment for sport participation such as track and field, tennis, swimming, etc. The participant was asked to note what protective equipment was worn for each SRC and the researchers would categorize the individuals based on the protective equipment provided.

In the survey, participants were asked to identify the mechanism of injury that was associated with each SRC. For each SRC reported, the participants indicated which MOI was present at time of injury. The participants could only choose one of these MOIs: Player-to-player, player-to-implement, player-to-ground, player-to-inanimate object, player-to-animal, and indirect contact. All participants were provided the following definitions to determine what mechanism they should chose. Player-to-player would be an athlete coming in contact with any body part such as the head, shoulder, knee, etc., compared to a player-to-implement, which would be coming in contact with a ball, club, bat etc. Player-to-ground would be striking the playing surface such as the ground, floor, mat, etc. Player-to-animal would be the athlete coming in contact with an animal like a horse or bull. Finally, indirect contact would be if the athlete fell on their butt or had whiplash from contact with another person.

Time loss is the amount of time that an athlete may lose after sustaining a SRC and can be categorized many different ways. For this study, time loss was categorized from 0-14 days and 15 days-3 months. The research team determined that this categorization would work best due to most adults returning to athletic participation within 14 days.[42] This was also utilized to maintain statistical power within the study.

3.3.1. Implementation of the Survey

The researchers either emailed or mailed all interested ATs a recruitment letter and the survey to distribute to their student-athletes with a SRC history that occurred during high school or college athletic participation. Reminders were sent to all participating schools to encourage ATs to share the survey with their student-athletes. The ATs were given the option to distribute the survey via both methods. Student-athletes were given a blank envelope which was used to seal the survey before the survey was returned to the AT. Any sealed envelopes were locked in the AT's office until all surveys were returned to the research team. All paper versions were sent with a large pre-paid self-addressed return envelope to improve AT convenience and likelihood of receiving completed surveys.

3.4. Potential Problems and Alternative Strategies

If issues arose with the surveys they were resolved in the following manner. All paper versions mailed had tracking numbers on envelopes. This was in case the surveys got lost in the mail they were easily recovered. Researchers asked for participant contact information (email and phone number) in case there were questions regarding their responses. Participants were initially contacted by email and if no response was received,

the research team contacted the participant by phone. If contacting the student-athlete by phone was unsuccessful, researchers used the data the student-athlete originally provided. Common questions that needed clarification were what position the athlete was playing at time of injury, how many years they were participating in their current sport, and the number of days missed from sport participation. There were 28 total participants that needed to be contacted for clarification, with a 19 providing clarification. The researchers attempted to contact the participant to verify answers up to two times. All identifying information was removed before the data was analyzed.

3.4.1 Data Entry and Cleaning

All of the surveys completed through Qualtrics were exported into an Excel document. Once the completed paper versions of the surveys were received by the research team, the data were input by hand into the same Excel document. While entering the data, the research team had to occasionally reorder data (1st concussion to 5th concussion) due to some participants reversing the order when they completed the survey. This error was noticed by the research team during the duplicate entry process.

3.4.2 Category Reorganization

After the initial round of data analyses, it became evident that the time loss, MOI, and protective categories would need to be re-grouped. As expected, we had more participants that reported a history of 1 (n=54) and 2 (n=32) concussions than 3 (n=19), 4 (n=9), and 5 (n=4) concussions. Due to low numbers in several of the categories we compared the time loss between all concussions and found no statistically significant differences between concussions 1-4 (p=0.50). Not enough people reported a history of 5 concussions so the model would not support the inclusion of their data. Because time loss

was not different between concussions 1-4, the research team combined the data for these concussions to improve the study power as well as the generalizability of our findings. Concussion five was excluded from data analysis because only four participants reported a fifth concussion and the research team could not be sure if the time loss for this concussion was significantly different from concussions 1-4.

The research team determined during the statistical analyses that several of the original categories for time loss, MOI and protective equipment were not adequately powered. Researchers recategorized (0-14 days and 15+ days) time loss from the original survey answers (0-1 day, 2-3 days, etc.) because it was the best method to separate the participants into time loss groups while maintaining statistical power for our analyses. Previous research supports this categorization due to most adult individuals recovering from SRCs within 14 days.[42] One participant was excluded from all data analyses as an outlier because their SRC-related time loss was 12 months, more than 4 times longer than any other participant. Three of the possible MOIs that were listed on the survey, contact with an animal, contact with inanimate object, and indirect contact, were excluded from all analyses due to lack of statistical power. The original six categories can be found in Table 3.3. Regarding protective equipment, researchers determined that the statistical power was not strong enough to use the three original categories (high, low, and no) for protective equipment. Participants in the "no" category were combined into the "low" category to increase the statistical power. The research team justified combining the participants in the "no" group into the "low" group because the equipment worn in the low group does not help protect the skull, since there is no barrier between the skull and

the MOI. The data were analyzed using low and high levels of protective equipment in all statistical analyses.

3.5. Statistical Analysis

Descriptive statistics were conducted for all demographic data. The independent variables, protective equipment (low and high) and MOI (player-to-player, player-to-ground, player-to-implement), were analyzed as categorical data. Time loss was ordinal in nature (0-14 days and 15 days to 3 months). Research questions one and two were analyzed using a Chi-Square due to their assumed non-parametric distributions. All data was analyzed using the JMP Pro 14 (Statistical Analysis System (SAS), Cary, North Carolina) to determine statistical significance with a prior alpha of p=0.05.

Table 3.2 Research Questions and Statistical Analyses

Research Question	Description	IV	DV	Method
1	What is the association between the amount of equipment worn and the amount of time loss from SRC?	Protective equipment	Time loss from SRC	ChiSq
2	What is the association between MOI and SRC-related time loss?	MOI	Time loss from SRC	ChiSq

Table 3.3 Mechanism of Injury Categories

General Categories	MOI Categories
Person-to-Implement	Ball, puck, stick, bat, club, glove, throwing implement, high jump, pole vault bar/stick, rifle
Player-to-Inanimate Object*	Cooler, bleachers, goal, fence, wall, scoreboard, table, hurdle, balance beam, uneven bars, etc.
Indirect Contact*	Fell on my butt, whiplash from contact with another person
Player-to-Ground	Ground, floor, mat, or diving board/platform
Player-to-Player	Head-to-head, shoulder, knee, foot, elbow, etc.
Player-to-Animal*	Horse, bull

*The categories that were excluded from all statistical analyses due to low power.

3.6. Power Analysis

Assuming a two-sided type I error of .05 the study had 80% power to detect a moderate to large effect size (ES = 0.5) with 49 participants. We collected data for 54 participants.

4. MANUSCRIPT

The Effect of Protective Equipment and Mechanism of Injury on Time Loss from Sport-Related Concussions

ABSTRACT

Context: There are many factors that contribute to the amount of time loss experienced from a sport-related concussion (SRC), such as protective equipment and mechanism of injury (MOI). Current literature investigating the potential relationships between SRC, protective equipment and mechanism of injury (MOI) is lacking.

Objective: To determine the relationships between, protective equipment, MOI, and SRC time loss.

Design: Retrospective, cross-sectional study.

Setting: On-line survey

Subjects: 54 collegiate athletes (28 females, 26 males) between the ages of 18-23 years old (19.9 ± 1.29 years) who sustained a SRC while participating in high school or collegiate athletics.

Main Outcome Measures: Data were analyzed to determine the relationship between protective equipment (high, low) and MOI (player-to-player, player-to-ground, player-to-implement) with SRC time loss (0-14 days, 15 days to 3 months),

Results: 54 participants reported a total of 108 SRCs. When evaluating the breakdown of the total reported SRCs, there were 31 SRCs in the high equipment group and 77 SRCs in the low equipment group. Chi-Square analyses determined that there were no statistically significance differences between protective equipment or MOI and time loss ($p \geq 0.09$).

Conclusion: Although the findings from this study were not statistically significant, the data indicate that with 77 total SRCs participants in the low equipment group still sustain

SRCs. The time loss data support previous studies that show the majority of SRC injuries recover within 14 days. These findings suggest that increased efforts need to focus on sports with low protective equipment to determine the MOIs that increase their risk to improve player safety.

Key Words: Injury risk, Traumatic brain injury, Athletic participation

4.1 Introduction

Annually, an estimated 1.6-3.8 million sport related concussions (SRC) are sustained in the United States every year.[1] A concussion is a direct or indirect contact to the head, face, neck, or body, which results either in a collision between the brain and skull or in a strain on neural tissue and vasculature.[2] The results of these temporary alterations in neurological and neurocognitive functioning typically resolve within 1-2 weeks post-injury in adults.[2] All types and levels of sport are associated with SRCs incidence involving various amounts of protective equipment and mechanisms of injury (MOIs). Currently literature investigating the potential relationships between SRC, protective equipment and MOI is lacking. In addition, there is a dearth of information regarding the relationships between protective equipment and MOI with time loss from sport participation following SRC injuries. By improving our understanding of these relationships, it may be possible to decrease SRC time loss. SRC incidence may be reduced by improving athlete safety via improved protective equipment, player technique, and enforcement of sporting rules.

The relationship between protective equipment and SRC has not been well investigated, possibly because not all sports utilize protective equipment. There are multiple studies that investigate equipment in football,[3,4] soccer,[5] and ice hockey[6] and

researchers use this data to evaluate the incidence of SRC within that sport. Protective equipment is not and cannot be designed to prevent SRCs. While protective equipment is beneficial it may leave athletes at risk due to the false sense of security that the equipment provides. Kerr et al.[3] investigated the effectiveness of equipment worn during collegiate football practices and concluded that individuals who wore full protective equipment were 22 times more likely to sustain a SRC compared to helmet only practices. When wearing shells, compared to an individual in fully padded equipment, the individuals in shells were 2 times less likely to sustain a SRC. The authors concluded that less protective equipment decreases the risk of sustaining a SRCs. In a study investigating injuries related to ball contact, Fraser et al.[7] found that women's soccer had the highest percentage of time loss when sustaining an SRC compared to 10 other men's and women's sports. In soccer, there is no protective equipment worn on the head. This lack of protection combined with MOI (unsafe techniques, i.e. spearing, cross checking, etc.), stiffness of the implement (hard or soft), or other factors (anticipated vs. unanticipated contact) may be determining factors regarding time loss. The type of protective equipment worn may be associated with an individual's choice to assume risk and perform more dangerous MOIs.

Mechanism of injury may also be an important factor in predicting SRC risk and possibly the amount of time loss associated with a SRC. SRCs occur in all sports and have been associated with multiple mechanisms, such as player-to-player contact,[8-13] player-to-surface contact,[8-10,12] player-to-object contact, [8-10,12] and indirect contact.[9] Currently, it is not known what the most common MOI is across all sports since many sports have not investigated to date. Because all sports have different rules and require

various levels of protective equipment, it seems that the MOI is dependent on the sport. Fraser et al.[7] investigated SRCs sustained by ball-contact in 11 National Collegiate Athletic Association (NCAA) sports and concluded that softball and baseball had the highest risk of sustaining a SRC compared to the other nine sports. Compared to football, softball was about 8 times more likely to sustain a SRC and baseball was 6 times more likely to sustain a SRC by ball contact. Softball and baseball also ranked first (24.1%) and third (17.2%) respectively when it came to individuals losing 1-6 days of athletic participation. The sporting maneuvers, implements (bat and hard ball), and protective equipment (helmet) associated with baseball and softball are different compared to sports like football (full equipment, medium ball), lacrosse (helmet, shoulder pads, gloves, stick, hard ball), volleyball (medium ball), and soccer (medium ball, shin guards). The most common MOI in both baseball and softball was being hit by the ball instead of player-to-player contact, which is the most common SRC MOI in football[13] and soccer.[10] Currently SRC-related MOI research is lacking, but understanding the associations that MOI and protective equipment have with time loss could help researchers better understand how to improve player safety across all sports.

Currently, there are few studies investigating the associations between protective equipment, MOI, and time loss from SRC. Protective equipment and MOI appear to be intertwined since the amount of protective equipment has been found to be related to SRC MOI in certain sports.[14] Unfortunately, the relationship of these factors with SRC and time loss have not been investigated for a large number of sports. Research, like the studies conducted by Fraser et al.[7] and Kerr et al.,[3] are the few that have included multiple sports while investigating protective equipment, MOI, and SRC time loss. The

purpose of this study was to determine the relationships between SRC time loss, protective equipment, and MOI in student-athletes who had sustained a SRC while participating in high school or collegiate sports.

4.2 Methods

Recruitment Participant

The research team personally contacted the head athletic trainers (AT) at collegiate institutions through email asking for their assistance in recruiting their student-athletes to be participants in this retrospective concussion study. The student-athletes with a history of SRC were recruited and enrolled into this study via two mechanisms. Potential participants, with a previous, history of SRCs, either received an invitation email (Qualtrics.com link) that contained a description of the study and a link to the survey, or a paper version of study description, consent and survey from their respective athletic trainer (AT). All participants were consented via their chosen survey method. The ATs at each participating school were allowed to determine the most effective mechanism for their school. The ATs had the option to give the paper version to some student-athletes and the Internet-based version to other student-athletes. Once consent forms had been determined, the participants completed the survey (online or paper version) which asked a variety of questions about their five most recent SRCs.

Data from 54 participants (28 females, 26 males) were collected whose ages ranged from 18-23 years old (19.9 ± 1.29 years). Participants were considered eligible if: (1) the participants were between 18-35 years old, (2) on a current NCAA team, and (3) had a history of SRCs that occurred during organized high school or collegiate sport

participation. The participants were asked to consider the following questions to determine if their concussion occurred during organized sport participation: 1) Did the team have organized practices, 2) Did the team have a competition schedule, 3) Did the team have a coach, and 4) Did the team have a roster for the season. Participants were excluded by the following criteria: 1) not fluent in English, 2) visual impairments that could not be rectified with corrective lenses. The survey was not available in other formats to accommodate participants with visual impairments.

Survey

The purpose of the survey was to gather demographic, SRC history and related-time loss, sport, MOI, and protective equipment information for their five most recent injuries. The five most recent SRCs had to occur during high school or college and could have been sustained while participating in a school or club sponsored event. The demographic questions inquired about the participant's sex, age, nationality, and regional location of school. The participants were also asked about the MOIs (i.e., person-to-person, person-to-surface contact) and protective equipment (e.g. helmet, full face shield, eyes only shield, goggles, gloves, shoulder pads), and sport-related time loss associated with their most recent five concussions.

All participants were asked to note the sport in which they were currently participating, as well as the sport in which they sustained there SRC in at the beginning of the survey. The participants were asked to note what protective equipment was worn at the time of each concussion. The research team also decided to categorize protective equipment into high and low based on the sport that was indicated for each SRC. The

protective equipment answers included, but were not limited to hard strapped helmet, plastic unstrapped helmet, mouth guard, shoulder pads, etc.

In the survey, participants were asked to identify the MOI that was associated with each SRC. The participants could only choose one of these MOIs: Player-to-player, player-to-implement, player-to-ground, player-to-inanimate object, player-to-animal, and indirect contact. All participants were provided the following definitions to determine what mechanism they should chose. Player-to-player would be an athlete coming in contact with any body part such as the head, shoulder, knee, etc. Player-to-implement is defined as coming in contact with a ball, club, bat etc. Player-to-ground would be striking the playing surface such as the ground, floor, mat, etc. Player-to-animal would be the athlete coming in contact with an animal like a horse or bull. Finally, indirect contact would be if the athlete fell on their butt or had whiplash from contact with another person.

Time loss is the amount of time that an athlete may be withheld from sport participation after sustaining a SRC. For this study, time loss was categorized from 0-14 days and 15 days to 3 months. The research team determined that this categorization would work best due to a majority of the participants returning within 14 days.[15] This was also utilized to maintain statistical power within the study.

Implementation of the survey

The research team sent either a recruitment email and a link to the SRC survey, via Qualtrics.com, or a paper version of both documents to all interested ATs to distribute to their student-athletes with a SRC history occurring during high school or collegiate athletics. Out of the 20 participating schools, 15 requested the electronic survey and 5

requesting the paper survey. Reminder emails were sent to all participating schools to encourage ATs to share the survey with their student-athletes. Schools could also request to have both the internet-based survey and the paper version. All paper versions were sent with a pre-paid self-addressed return envelope to improve AT convenience and likelihood of receiving completed surveys.

Procedures

The research team contacted head ATs at all 1,084 NCAA Division I-III institutions inquiring about participation in this concussion study. The names and emails of all head ATs were found on the institution's athletic website. If the AT responded to the initial email expressing interest in participation, the researcher would ask the AT to state the institution name, the institution's address, the NCAA division, and the version of the survey that they would prefer. The research team shared the electronic or paper documents with the interested ATs, who then distributed them to their eligible student-athletes. Participants who chose the paper version sealed their completed survey in a blank envelope before submitting their survey to their AT. When all surveys had been completed, the surveys were mailed back to the researchers. After the surveys were received, the data were inputted into Microsoft Excel for statistical analysis. Since all surveys contained identifying information, all participants were assigned a randomly chosen number prior to data analysis. Identifying information, such as phone numbers and email, was necessary in case clarification for one of more of their answers was needed by the research team. Athletes were first contacted by email, if no response was received, the research team called the athlete with the phone number provided. The

researchers attempted to contact the participant to verify answers up to two times. In total, researchers contacted 28 participants for clarification.

Data Collection

Prior to data collection, a pilot study was conducted to determine the validity of the survey. The survey used in the pilot study was similar to the one used on the participants for this study. The pilot study resulted in the research team making minor changes, such as wording, to improve the answers provided by participants. There were a total of 10 former student-athletes that completed the pilot study.

A retrospective research design was utilized for this study. All data were collected from various colleges and universities around the United States via paper and electronic surveys. While the surveys were identical regarding the questions the participants were asked, there were still some differences that should be noted. The paper version allowed the participants to explain or write more specific answers, but on the internet version this was not an option. The internet version contained all pre-determined answers to standardize the answers and to limit participant burden and confusion. For example, the participants completing the internet version could only select categories such as 8-14 days, 15-21 days, whereas a participant completing the paper version could write 9 days, 17 days, etc. The independent variables for this study are protective equipment (low and high) and MOI (player-to-player, player-to-surface, player-to-implement) with time loss (0-14 days and 15days to 3months) being the dependent variable. For protective equipment, participants were separated into two categories: high levels of protective equipment and low levels of protective equipment. Any participant that identified as wearing no levels of protective equipment were included in the low protective equipment

category. The sport indicated for each SRC was used to determine the categorization of all participants regarding protective equipment. Any participant in the high category identified as participating in football, ice hockey, and men's lacrosse. The equipment type for these sports is much greater due to the physical nature of the sport, which requires more protective equipment to participate. A participant would be included in the high equipment group if the sport required the participant to wear shoulder pads, helmet, facemask, etc. Low levels of protective equipment identified with sports that require no-to-minimal protective equipment to participate. Examples of these sports would be tennis, basketball, soccer, baseball, softball, etc. All participants submitted identifying information to assist with data clarification, but the data were de-identified by the research team prior to data analysis.

Data Entry and Cleaning

All of the surveys completed through Qualtrics were exported into an Excel document. Once the completed paper versions of the surveys were received by the research team, the data were input by hand into the same Excel document. While entering the data, the research team had to occasionally reorder data (1st concussion to 5th concussion) due to some participants reversing the order when they completed the survey. This error was noticed by the research team during the duplicate entry process. Researchers recategorized (0-14 days and 15+ days) time loss from the original survey answers (0-1 day, 2-3 days, etc.) because it was the best method to separate the participants into time loss groups while maintaining statistical power.

The research team determined that this categorization would work best due to most adults returning to athletic participation within 14 days. Three of the possible MOIs that were listed on the survey, contact-with-animal, contact-with-inanimate object, and indirect contact, were excluded from all analyses due to lack of statistical power. The descriptive data for the original six categories can be found in Table 4.1.

Statistical Analysis

Descriptive statistics were conducted for all demographic data. The final independent variables, protective equipment (low and high) and MOI (player-to-player, player-to-surface, player-to-implement), were analyzed as categorical data. Time loss was ordinal in nature (0-14 days and 15 days to 3 months). Data were analyzed using a Chi-Square due to their assumed non-parametric distributions. JMP Pro 14 (Statistical Analysis System (SAS), Cary, North Carolina) was used to conduct all chi square analyses to determine statistical significance with a prior alpha of p=0.05.

4.3 Results

The research team contacted 1,084 NCAA schools, with 20 schools agreeing to participate. Initially 78 participants were enrolled, but 24 participants were excluded due to surveys being incomplete. A total of 54 student-athletes (age 19.9 ± 1.29 years, n=28 females, 26 males) across all three NCAA divisions were enrolled in the study. Women's soccer was the most-represented sport (N= 24.1%) of the sample followed by men's lacrosse (N= 16.6%), men's soccer (N= 12.9%), women's lacrosse (N= 9.25%) and women's basketball (N= 9.25%) (Table 4.2**)**. Across the five concussions that participants could have reported, there were 118 total concussions reported. The

participants completed 36 internet surveys and 18 paper surveys. Due to an insignificant Wilk's Lamda ($p=0.51$), the research team combined concussions one through four to increase the statistical power of the results. Concussion five was excluded due to low reporting numbers ($n=4$). After concussions one through four were combined, there were a total of 108 concussions from 54 participants. The distribution of the 108 SRCs across sport are demonstrated in Table 4.3. From the 108 reported concussions, there were 77 concussions in the low equipment group and 31 concussions in the high equipment group. None of the protective equipment or MOI groups were significantly different ($p \geq 0.09$). All MOI and protective equipment results can be found in Table 4.4 and Table 4.5, respectively.

Of the 108 concussions reported, 84 (78%) of the concussions sustained returned to full athletic participation within 14 days when regardless of the level of protective equipment worn. For protective equipment, there were four times more individuals (OR=0.67) that returned within the 14-day time period compared to the 15+ days group which only accounted for 22% of the participants. It was determined that 23 (74%) of concussions in the high group returned within the typical 14-day time period while 61 (74%) of concussions in the low group returned within the same period of time. Similar to protective equipment, 78% of individuals returned to full sport participation within 14 days regardless of MOI. While player-to-player contact was the most common mechanism reported with 45 concussions, it was actually player-to-implement contact that resulted in a participant taking more than 14 days to return to full athletic participation. While evaluating the MOIs, 34% of participants who experienced more

than 14 days of athletic participation, followed by player-to-player contact (24%), and finally player-to-ground (8%).

4.4 Discussion

This study determined that protective equipment and MOI are not related to SRC time loss. Student-athletes, regardless of protective equipment and/or MOI, are at risk of sustaining a SRC. Our study supports previous research that states that the majority of collegiate athletes recover from a SRC within 14 days and that player-to-player contact is the most common mechanism. While most researchers focus on the individuals who participate in sports that require a significant amount of protective equipment, the data from our study shows that participants in the low group still sustain concussions. With 71% of individuals identifying as wearing low levels of protective equipment, our study demonstrates a need for further investigation into this group of individuals.

While player-to-player contact was the most common MOI in this study, it was not the mechanism that resulted in the greatest SRC time loss. While the MOI group differences were not statistically different, player-to-implement contact resulted in a greater percentage of participants taking longer than 14 days to return to full athletic participation compared to the other two categories. A total of 34% of participants who sustained a SRC from coming in contact with a playing implement returned after the typical 14-day time period. Player-to-player contact and player-to-ground were second and third respectively at 24% and 8%. The findings may be clinically significant because the data shows participants that sustain a player-to-implement take more time to recover compared to participants from other mechanisms. One reason player-to-implement

mechanisms may result in more time loss could be the student-athlete's inability to anticipate the impact and naturally protect the body from the impact. Delaney et al. noted that head-to-head contact was the most common MOI in soccer, and football, but states that individuals in ice hockey were more likely to sustain contact from another body part or contact with an object such as a stick.[14] While player-to-player contact is the most common MOI, it should be stated that a majority of sports included in this study are not related to contact sports. While there is player-to-player contact in those sports, the player-to-player contact is not supposed to happen. Understanding that different mechanisms present across all sports could help athletic trainers recognize all potential mechanisms and thus putting the athlete's safety first. As healthcare providers, it is important to recognize that mechanisms other than player-to-player contact could result in time loss from SRC. While athletic trainers cannot reduce the chances of a student-athlete experiencing time loss from a SRC, there are many alternative solutions to reduce the incidence of SRCs.

As discussed above, our data demonstrated a higher percentage of SRCs related to player-to-ground and player-to-implement than several past studies. These results are most likely the product of the high number of participants who reported that their SRCs occurred in low equipmented sports. Typically sports that report wearing low levels of protective equipment do not intentionally engage in player-to-player contact. The results from this study show there is no association between the mechanism present at time of injury and the level of protective equipment As stated above, Kerr et al.[3] found less protective equipment reduced the incidence of player-to-player contact. While our study design is different from those done by Kerr et al.[3] and Fraser et al.[7], our study still helps

support their findings by demonstrating that athletes who wear less protective equipment are at risk for sustaining SRCs. Regardless of level of protective equipment, other mechanisms besides player-to-player may still increase an athlete's risk of sustaining a SRC. Investigating these mechanisms may help healthcare providers and future researchers understand the effects these mechanisms have on SRCs. The results of this study, as well as results from previous research, do not support the purpose statement by demonstrating there is not an association between MOI, protective equipment, and the amount of time loss experienced from SRCs. Understanding the time loss experienced across all sports and not just specific ones, which will help improve player safety.

A study conducted by Fraser et al.[7] determined that compared to football, softball was 8 time more likely to sustain a ball-contact SRC and baseball was 6 times more likely to sustain a ball-contact SRC. Individuals that participate in softball and baseball wear significantly less protective equipment compared to individuals that participate in football. The data from our study supports their findings that participants in the low equipment in conjunction with a player-to-implement demonstrates that SRCs still occur in this population groups. This information could be beneficial for athletic trainers working with these low protective equipment teams. This would be helpful information for those athletic trainers because it may identify possible risk factors (mechanisms, protective equipment, etc.) which, in turn, will keep the athlete safe. While protective equipment and MOI did not have a significant impact on the amount of time loss from SRCs in this study, it could quicken the evaluation process, which will improve the qualities of patient care provided to the athlete. Future studies with larger sample sizes and including more sports is needed. With more participants, researchers would be able

to have enough statistical power to analyze all possible categories and determine if differences did exist. If protective equipment and MOI are related to SRC time loss, then this information could help ATs recognize at risk student-athletes who do not participate in the typically associated SRC sports. While past research has primarily focused on high equipmented sports, this study provides evidence that student-athletes in no to low equipmented sports also sustain SRCs. Therefore, more clinical and research attention should be directed toward this group of athletes.

There are many limitations to this study that should be noted. A majority of our participants (78%) returned to full sport participation within 14 days regardless of the level of protective equipment worn. The number of participants in the MOI categories were not evenly distributed, which makes it difficult to determine if one mechanism resulted in more time loss compared to other mechanisms. The research team overcame this limitation by converting the raw number to percentages. Our participants were primarily in the no-to-low equipment group. This decreases the generalizability of our findings to sports that wear high levels of protective equipment, however, it improves our finding's generalizability to the no and low equipment sports. Future research for this study is to conduct a similar study, but with more participants across all MOIs and all levels of protective equipment. With more participants, researchers would be able to determine if there are certain sports that are more likely to experienced time loss compared to others.

Understanding all factors regarding MOI or protective equipment may cause athletic trainers to be more proactive in the evaluation of suspected SRCs, especially during atypical presentations. This could also bring attention to sports where research is

lacking. With proper knowledge of the sport technique, in conjunction with SRC risk knowledge as detailed in this study, the health care of student-athletes can be improved by increased awareness of high-risk situations and MOIs. Our findings, while not statistically significant, support additional research investigating time loss from SRC concerning sports that use low levels of protective equipment since information in this area is lacking. The clinical significance will support further research by involving all sports, not just football, ice hockey, and soccer, which could help determine the relative risk of an athlete experiencing time loss from a SRC. This will improve player safety and improve the quality of care provided by athletic trainers.

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Table 4.1 Time Loss from Sport Participation by Mechanism of Injury—Includes all Mechanisms; N (%)

		Mechanism of Injury						
		Player-to-Implement	Player-to-Ground	Player-to-Player	Player-to-Inanimate Object*	Player-to-Animal*	Indirect Contact*	Total
Time Loss	0-14 Days	16 (14.04)	23 (20.18)	45 (39.47)	0 (0)	1 (0.88)	3 (2.63)	88 (77.19)
	15 Days-3 Months	8 (7.02)	2 (1.75)	14 (12.28)	2 (1.75)	0 (0)	0 (0)	26 (22.81)
	Total	24 (21.05)	25 (21.93)	59 (51.75)	2 (1.75)	1 (0.88)	3 (2.63)	114

*Indicates categories that were excluded from all statistical analyses due to lack of statistical power.
Player-to-Implement: Athlete coming in contact with a ball, puck, stick, bat, club, etc.
Player-to-Ground: Athlete coming in contact with the floor, ground, mat, etc.
Player-to-Player: Athlete coming in contact with another athlete's head, shoulder, knee, foot, etc.
Player-to-Inanimate Object: Athlete comes in contact with coolers, bleachers, goal, fence, wall, etc.
Player-to-Animal: Athlete comes in contact with an animal such as a bull or horse.
Indirect Contact: Athletes falls on butt or sustains whiplash from coming in contact with another person. Athlete did not sustain a direct blow to the head.

Table 4.2 Distribution of Participants by Sport

SPORT	NUMBER OF PARTICIPANTS, N (%)
BASEBALL	3 (5.6)
BASKETBALL—MEN'S	2 (3.7)
BASKETBALL—WOMEN'S	5 (9.3)
FOOTBALL	3 (5.6)
GOLF—WOMEN'S	1 (1.9)
LACROSSE—MEN'S	9 (16.7)
LACROSSE—WOMEN'S	5 (9.3)
SOCCER—MEN'S	7 (12.9)
SOCCER—WOMEN'S	13 (24.1)
SOFTBALL	1 (1.9)
SWIMMING—WOMEN'S	1 (1.9)
TRACK AND FIELD (NON-POLE VAULTER)—MEN'S	1 (1.9)
TRACK AND FIELD (NON-POLE VAULTER)—WOMEN'S	1 (1.9)
VOLLEYBALL—MEN'S	1 (1.9)
VOLLEYBALL—WOMEN'S	1 (1.9)
TOTAL	**54 (100)**

Number and percentages of participants based on their current college or university sport

Table 4.3 Distribution of Reported SRCs by Sport

SPORT	NUMBER OF SRC, N (%)
BASEBALL	2 (1.9)
BASKETBALL—MEN'S	1 (0.9)
BASKETBALL—WOMEN'S	13 (12.0)
FIELD HOCKEY	1 (0.9)
FOOTBALL	17 (15.7)
LACROSSE—MEN'S	13 (12.0)
LACROSSE—WOMEN'S	5 (4.6)
SOCCER—MEN'S	13 (12.0)
SOCCER—WOMEN'S	32 (29.6)
SOFTBALL	1 (0.9)
RODEO—MEN'S	1 (0.9)
VOLLEYBALL—MEN'S	1 (0.9)
VOLLEYBALL—WOMEN'S	6 (5.5)
WRESTLING	2 (1.9)
TOTAL	**108 (100)**

Number and percentages demonstrate the distribution of total reported SRCs across all sports.

Table 4.4 Time Loss from Sport Participation by Mechanism of Injury—Analyzed Variables; N (column, row, table percentage)

		Time Loss		
		0-14 Days	15 Days to 3 Months	Total
Mechanism of Injury	Player-to-Implement	16 (14. 81, 66.6, 19.0)	8 (7.41, 33.3, 33.3)	24 (22.2, 100, 22.2)
	Player-to-Ground	23 (21.30, 92.0, 27.4)	2 (1.85, .08, 8.3)	25 (23.15, 100, 23.15)
	Player-to-Player	45 (41.67, 76.2, 53.6)	14 (12.96, 23.7, 58.4)	59 (54.6, 100, 54.63)
	Total	84 (77.78, 77.78, 100)	24 (22.22, 22.22, 100)	108 (100)

Player-to-Implement: Athlete coming in contact with a ball, puck, stick, bat, club, etc.
Player-to-Ground: Athlete coming in contact with the floor, ground, mat, etc.
Player-to-Player: Athlete coming in contact with another athlete's head, shoulder, knee, foot, etc.
Each cell contains the total number of participants (N) followed by the associated column, row, and table percentages.

Table 4.5 Time Loss from Sport Participation by Level of Protective Equipment Worn; N (column, row, table percentage)

		Time Loss		
		0-14 Days	15 Days to 3 Months	Total
Level of Protective Equipment	High	23 (21.30, 74.1, 27.3)	8 (7.41, 25.8, 33.3)	31 (28.7, 100, 28.7)
	Low	61 (56.48, 79.2, 72.7)	16 (14.81, 20.7, 66.7)	77 (71.3, 100, 71.3)
	Total	84 (77.78, 77.78, 100)	24 (22.22, 22.22, 100)	108 (100)

High Level of Protective Equipment: Sports that require a significant amount of protective equipment to participate such as shoulder pads, helmet, facemask, etc. (i.e. football, ice hockey, men's lacrosse, lacrosse goalies (men's and women's), and catchers)
Low Level of Protective Equipment: Sports that require little to no protective equipment to participate such as goggles, shin guards, (i.e. tennis, basketball, baseball/softball, women's lacrosse, etc.)
Each cell contains the total number of participants (N) followed by the associated column, row, and table percentages.

APPENDIX 1: RECRUITMENT LETTER

Hello current NCAA student-athlete!

Anya Malloch, a graduate student at Texas State University, is conducting a research study to help athletic trainers to learn more about all athletes who have experienced sport-related concussions while participating in high school and collegiate sports. You are a current NCAA athlete who has sustained a sport-related concussion while participating on a high school (school or club) or a collegiate (varsity) sports team. A sport-related concussion is a brain injury caused by direct or indirect contact to the head, face, neck, or body, which results either in a collision between the brain and skull or stretching of the nerves. A sport-related concussion may result in temporary changes in memory, balance, and emotions that typically get better within 1-2 weeks in adults. For the purposes of this study, all reported concussions must have occurred during an organized athletic practice or competition in high school (club or school sports) or college (varsity). The concussions may be diagnosed (you reported it to a healthcare provider: school nurse, AT, physician, etc.) or undiagnosed (you did not report it to a healthcare provider). To protect confidentiality, your athletic trainer will not have access to your responses. The research team are the only individuals who will access to your responses.

Participation in this study is voluntary. To ensure the confidentiality of your information we are providing you with a blank envelope. Please place your completed paper survey in this envelope, seal it, and then give it to your athletic trainer. Your athletic trainer will then put it in a larger storage envelope. The sealed envelopes will be stored in a locked cabinet in your athletic trainers' locked office until they are sent back to us at Texas State University. Once we receive your envelope, your name and contact information (identifying information) will be separated from your concussion information to protect your confidentiality. All responses will be kept confidential and stored on encrypted servers accessible only to the members of the research team that have been granted access to the server. Your name will be removed from your information and we will replace it with a deidentified code to improve the confidentiality of your information. Your information will be entered onto an excel spreadsheet that only includes the code and not your name Your data will be stored for a minimum of 3 years following the conclusion of the study. No identifying information will be used in any publications or presentations. That way no one will know that you participated in this study or be able to link your answers to your name

The attached survey will take approximately 20 minutes to complete. You must be at least 18 years old and have sustained a concussion while participating in a school or club-related sport while in high school or a varsity collegiate sport to participate in this study. Once you have completed this survey please place it in the attached blank envelope and give it back to your athletic trainer.

Before completing the attached survey, please complete the signature form below stating that you are consenting to participate in this research study.

This study involves minimal risks. The questions within the survey do not impose any threat to your health or well-being. At most, you may experience slight emotional discomfort/unease in honestly answering some of the questions. We ask that you try to answer all questions to the best of your ability so we can help inform athletic trainers, coaches, and future athletes about behaviors that may decrease concussion risk and time loss; however, if a question makes you uncomfortable you may skip that question. You also will not directly benefit from this study. This study may indirectly benefit current and future athletes because this study addresses several concussion topics concerning athletes that have not previously been investigated.

If you have any questions or concerns about this survey feel free to contact Anya Malloch or her faculty advisor Dr. Missy Fraser:

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Health and Human Performance
aem217@txstate.edu

Missy Fraser, PhD, ATC, LAT
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O: 512-245-4373

Thank you in advance for your consideration and cooperation with this important study identifying factors that may increase SRC-related risk and time loss.

This project 5599 was approved by the Texas State IRB on October 2, 2018. Pertinent questions or concerns about the research, research participants' rights, and/or research-related injuries to participants should be directed to the IRB chair, Dr. Denise Gobert (512-245-5497; dgobert@txstate.edu) or to Monica Gonzales, IRB administrator (512-245-2314; meg201@txstate.edu).

_____ (initials) I have read the information provided by the research team. I understand the risks and benefits of participating in this study and consent to the research team using my information with the understanding that my name and all contact information will be removed prior.

_____ Date: / / 2019
Printed Name (in ink)

_____
Signature (in ink)

APPENDIX 2: SURVEY

Please use a blue or black pen.

1) Please indicate your sex by circling the answer below.

   Female Male

2) Please write **today's date**. It must be written mm/dd/yyyy. For example, if today is August 7th 2050, it should be written, 08/07/2050.

   _____

3) Please put your date of birth. It must be written mm/dd/yyyy. For example, if your date of birth is April 9th 2000, it should be written, 04/09/2000.

   _____

4) Please circle your current age.

   17 18 19 20 21 22 23 24 25 26 27 28 29 30+

5) Circle the university-sponsored sport that you are currently participating in at your university. Please write M for Men's or W for Women's next to the sport that is circled.

   If you are a multi-sport collegiate athlete, circle all that apply.

Archery	Baseball	Basketball	Bowling
Boxing	Cheer	Cross Country	Dance Team
Diving	Equestrian (English)	Equestrian (Western)	Fencing
Field Hockey	Football	Golf	Gymnastics
Ice Hockey	Lacrosse	Pistol	Rifle
Rowing	Rugby	Sailing	Sailing (Offshore)
Skiing (Downhill)	Skiing (Cross Country)	Soccer	Softball
Squash	Swimming	Track and Field (Non Pole-Vaulters)	Track and Field (Pole Vaulter)
Volleyball (Court)	Volleyball (Sand)	Water Polo	Wrestling
Other			

Use the following definition to answer question 6 and 9.
Only include **organized sports.**

Being a member of an **organized sport** must meet the following criteria:
1) If the team you competed for had organized practices
2) If the team you competed for had a set competition schedule
3) If the team you competed for had a coach
4) If the team you competed for had an official roster

6) How many years have you played the sport circled above? If more than one sport is selected, please note how many years each sport has been played.

Sport 1:_____ Sport 2:_____

7) Are you currently participating in your sport? (i.e. conditioning, practicing, competitions)

___Yes (Go to question 9) ___No (Go to question 8)

8) If you answered "No" for question 7, please explain the reason below. Example: Injury (ankle sprain, ACL tear, concussion), academics, etc.

_____

9) Please **circle all** of the organized sports you have **ever** participated in. Include the collegiate sport you are currently participating in this year. Please write M for Men's or W for Women's next to the sport(s) that is circled.

Archery	Baseball	Basketball	Bowling
Boxing	Cheer	Cross Country	Dance Team
Diving	Equestrian (English)	Equestrian (Western)	Fencing
Field Hockey	Football	Golf	Gymnastics
Ice Hockey	Lacrosse	Martial Arts	Pistol
Racquetball	Rifle	Rodeo	Rowing
Rugby	Sailing	Sailing (Offshore)	Skiing (Downhill)
Skiing (Cross Country)	Soccer	Softball	Squash
Swimming	Track and Field (Non Pole-Vaulters)	Track and Field (Pole Vaulter)	Ultimate Frisbee
Volleyball (Court)	Volleyball (Sand)	Water Polo	Water Sports (surfing, water skiing, etc.)
Wrestling	Other		

10) What was your **academic status** at the start of the 2018-2019 academic year (Not your athletic eligibility)

____Freshman ____Sophomore ____Junior ____Senior

____5th year Senior ____6th year Senior ____Graduate Student

11) What was your **athletic eligibility status** at the start of the 2018-2019 academic year.

____Freshman (Includes red-shirt freshman) ____Sophomore ____Junior

____Senior ____5th year senior (only if you had a red-shirt year)

____Awarded 6th year super senior (Medical red-shirt) ____Graduate Student

For questions 12-15 use the following definitions.

*A **concussion** is a blow to the head followed by a variety of symptoms that may include any of the following: headache, dizziness, loss of balance, blurred vision, "seeing stars", getting "dinged", feeling in a fog or slowed down, memory problems, poor concentration, nausea, or throwing-up. Getting "knocked out" or being unconscious does NOT always occur with a concussion.*

A sport-related concussion is a concussion that occurs while participating in an organized

12) Have you ever had a concussion?

___Yes ____No ____Unsure

13) How many concussions have you **ever** had in your life time? Include **all** concussions (sport-related and non-sport-related) whether they were diagnosed by a healthcare provider or not. **Please circle one answer below.**

For example: If you sustained **1** diagnosed concussion from baseball, **1** diagnosed concussion from football, **1** undiagnosed concussion from basketball, and **1** undiagnosed concussion from a car accident you would answer **4**.

1 2 3 4 5 6 7 8 9 10 11
12 13 14 15 16 17 18 19 20+

14) How many sport-related concussions have you had that were **diagnosed** by an athletic trainer or a doctor? **Only circle one number.**

For example: If you sustained **1** diagnosed concussion from baseball, **1** diagnosed concussion from football, **1** undiagnosed concussion from basketball, and **1** undiagnosed concussion from a car accident you would answer **2**.

The answer would be 2 because the 3rd and 4th concussions were not diagnosed/ or not sport-related concussions.

1 2 3 4 5 6 7 8 9 10 11
12 13 14 15 16 17 18 19 20+

15) How many sport-related concussions have you had that were **NOT diagnosed** by a medical professional? **Only circle one number.**

For example: If you sustained **1** diagnosed concussion from baseball, **1** diagnosed concussion from football, **1** undiagnosed concussion from basketball, and **1** undiagnosed concussion from a car accident you would answer **1**.

The answer would be 1 because the 1st and 2nd were diagnosed and 4th was not sport-related.

Include the undiagnosed concussion if:

a. You didn't know at the time what the signs or symptoms of a concussion were, but after reading the description above you now think you may have had a concussion.

b. You had any of the signs of symptoms of a concussion, but didn't tell anyone.

c. You experienced the signs and symptoms of a concussion and you went to see an athletic trainer or doctor and they told you that you did not have a concussion.

0 1 2 3 4 5 6 7 8 9 10+

IF YOU CIRCLED "0" FOR QUESTION 15, SKIP QUESTION 16.

16) Why did one or more of your concussion(s) go undiagnosed? (Please check all that apply)

____You did not realize it was a concussion

____You did not think it was serious.

____You did not want to miss time.

____You felt pressured by your coach, teammates, or parent(s) to keep playing.

____You were too embarrassed to tell someone.

____Your coach, teammates, or parent(s) would have thought you were weak.

____Your coach, teammates, or parent(s) would have thought you were faking it to get out of participation.

____You did not think anyone would have believed you.

____You did not report the concussion because you did not believe in concussions.

____You were worried that you would become medically disqualified from athletics because you had already experienced concussions previously.

____Your school did not have a healthcare professional (i.e. athletic trainer or nurse) to diagnose your concussion.

____You pulled yourself out of participation because you knew you had a concussion.

____You ignored your concussion because you thought it would go away.

____You experienced the signs and symptoms of a concussion and you went to see an athletic trainer or doctor and they told you that you did not have a concussion.

17) **Please complete the following questions for your 5 most recent diagnosed or undiagnosed sport-related concussions.**

Please try to list your concussions from most recent (2018 = Concussion 1) to least recent (2012 = Concussion5).

If you have sustained less than 5 concussions, please leave the additional rows blank.

For the following questions, please reference the sports listed in Question 9 and write that sport on the line. Please circle W (women's) or M (men's) next to the sport you select. You will only check the concussion status line if you are <u>currently</u> being treated for a concussion. Also circle if the concussion occurred in a club (C) or school (S) sponsored sport. On the position line, please write the position you were playing when each concussion was sustained.

	Month	Year	Concussion Status	Club (C) School (S)	Sport	Sex	Position
Concussion 1				S C		M W	
Concussion 2				S C		M W	
Concussion 3				S C		M W	
Concussion 4				S C		M W	
Concussion 5				S C		M W	

<u>ONLY ANSWER QUESTION 18, IF YOU WROTE "OTHER" ON THE SPORT LINE FOR ANY OF THE SPORT-RELATED CONCUSSIONS DESCRIBED IN QUESTION 17.</u>

18) If you wrote "Other" for any of the concussion above, please explain what activity you were doing at the time of your concussion.
Example: Concussion 1 = Skydiving
Example: Concussion 4 = Rock Climbing

Concussion 1: _____

Concussion 2: _____

Concussion 3: _____

Concussion 4: _____

Concussion 5: _____

For questions 19, use the following definition.

Return-to-Play Protocols usually take 3-7 days to complete, but may take longer. Athletes usually start with a light cardio workout (biking) on the first day. Each day their workout gets harder until they are back to full participation in their sport.

19) Did you complete a Return-to-Play protocol prior to returning to full sport participation?

Concussion 1: ____Yes ____No ____Unsure

Concussion 2: ____Yes ____No ____Unsure

Concussion 3: ____Yes ____No ____Unsure

Concussion 4: ____Yes ____No ____Unsure

Concussion 5: ____Yes ____No ____Unsure

20) How did each concussion occur? (Only circle the situation associated with each concussion—**Only one choice can be circled per concussion**) Example: a=1, 3, 4 b=2 c=5

a) Another person's body hit my head (head-to-head, shoulder, knee, foot, elbow, etc.
Concussion: 1 2 3 4 5

b) My head hit the ground, floor, mat, or diving board/platform
Concussion: 1 2 3 4 5

c) My head hit an inanimate object (cooler, bleachers, goal, fence, wall, scoreboard, table, hurdle, balance beam, uneven bars, etc.)
Concussion: 1 2 3 4 5

d) My head was hit by a piece of athletic equipment (ball, puck, stick, bat, club, glove, throwing implement, high jump, pole vault bar/stick, rifle)
Concussion: 1 2 3 4 5

e) My head was hit by an animal (horse, bull, deer, etc.) – Equestrian, rodeo, cross country, etc.
Concussion: 1 2 3 4 5

f) My head didn't hit anything (fell on my butt, whiplash from contact with another person)
Concussion: 1 2 3 4 5

21) Who did you report your concussion to within 3-5 days post-injury? (Only circle the person(s) associated with each concussion—**More than one person can be circled for each sport-related concussion**)
Example: b=concussion 1-5 c=concussion1-3 d=1-3 a and e not selected

a) No One
Concussion: 1 2 3 4 5

b) Parent/Guardian
Concussion: 1 2 3 4 5

c) Athletic Trainer
Concussion: 1 2 3 4 5

d) Physician
Concussion: 1 2 3 4 5

e) School Nurse
Concussion: 1 2 3 4 5

22) How many full days of **athletic participation** did you miss for each of the concussions you listed?

Concussion 1: _____ days

Concussion 2: _____ days

Concussion 3: _____ days

Concussion 4: _____ days

Concussion 5: _____ days

23) How many full days of **school** did you miss for each of the concussions you listed?

Concussion 1: _____ days

Concussion 2: _____ days

Concussion 3: _____ days

Concussion 4: _____ days

Concussion 5: _____ days

For question 24, use the following definition.

Reduced Academic Load is attending school less than full time for 1 or more days; extensions or assistance with homework, quizzes, and/or exams.

24) How many days did you have a **reduced academic load** from each of the concussions you listed?

Concussion 1: _____ days

Concussion 2: _____ days

Concussion 3: _____ days

Concussion 4: _____ days

Concussion 5: _____ days

For question 25, use the following definitions.

Required Equipment: Any protective device that is mandatory for sport participation
Examples: football = Hard strapped helmet, full face shield/mask (metal), shoulder pads, mouth guard

Optional Equipment: Any protective device that is not mandatory for sport participation
Examples: softball/baseball = face mask; football = rib belt, gloves—gripping; women's lacrosse = hard strapped helmet

25) Using the concussion information entered from question 17, please check all of the **required protective equipment** and **optional protective equipment** that you were wearing when each of your concussions (1-5) occurred.

- If your sport does not include any equipment, circle 'None' under 'Required Protective Equipment'.
- Only circle the protective equipment that is worn in the sport associated with each concussion.

	Required Equipment	Optional Equipment
EQUIPMENT WORN	**Concussion**	**Concussion**
None	1 2 3 4 5	
Hard strapped helmet (football, ice hockey, men's lacrosse, equestrian, skiing)	1 2 3 4 5	1 2 3 4 5
Plastic unstrapped helmet (softball, baseball)	1 2 3 4 5	1 2 3 4 5
Goalie/catcher mask	1 2 3 4 5	1 2 3 4 5
Padded headgear (boxing, martial arts, soccer)	1 2 3 4 5	1 2 3 4 5
Headgear (wrestling)	1 2 3 4 5	1 2 3 4 5
Soft caps (rugby, water polo)	1 2 3 4 5	1 2 3 4 5
Full face shield/mask (plastic)	1 2 3 4 5	1 2 3 4 5
Full face shield/mask (metal)	1 2 3 4 5	1 2 3 4 5
Half face shield/mask (plastic)	1 2 3 4 5	1 2 3 4 5
Eye shield/mask (football)	1 2 3 4 5	1 2 3 4 5
Fielder's mask (softball)	1 2 3 4 5	1 2 3 4 5
Goggles (lacrosse, swimming, skiing)	1 2 3 4 5	1 2 3 4 5
Mouth guard	1 2 3 4 5	1 2 3 4 5
Neck protectors - flat board, bull collar	1 2 3 4 5	1 2 3 4 5
Throat protector (goalies, catchers)	1 2 3 4 5	1 2 3 4 5
Shoulder pads	1 2 3 4 5	1 2 3 4 5
Rib belts	1 2 3 4 5	1 2 3 4 5
Chest protector	1 2 3 4 5	1 2 3 4 5
Life jacket (sailing)	1 2 3 4 5	1 2 3 4 5

Glove(s) - Padded (boxing, ice hockey, men's lacrosse, and goalies)	1 2 3 4 5	1 2 3 4 5
Glove(s) - Grip (hitting)	1 2 3 4 5	1 2 3 4 5
Glove - Catching (baseball/softball)	1 2 3 4 5	1 2 3 4 5
Wrist guard	1 2 3 4 5	1 2 3 4 5
Shin guards - soccer	1 2 3 4 5	1 2 3 4 5
Hitter shin guard (baseball/softball)	1 2 3 4 5	1 2 3 4 5
Knee pads	1 2 3 4 5	1 2 3 4 5
Goalie leg pads	1 2 3 4 5	1 2 3 4 5
Thigh protectors (football, ice hockey)	1 2 3 4 5	1 2 3 4 5

26) Did any of the 5 concussions noted in question 17 occur within 2 weeks of each other? Check the line below.

_____ Yes

_____ No

_____ Unsure

IF YOU CHECKED "NO" FOR QUESTION 26, SKIP QUESTION 27. DO NOT FILL OUT THE TABLE BELOW. CONTINUE ONTO QUESTION 28.

27) Please indicate which of your concussions occurred within 2 weeks of each other using the concussion order documented in the above questions.

This may have occurred more than once. Therefore, you have the ability to do this up to two times.

For example: If Concussion 1 occurred on Oct 1, 2000 and Concussion 2 occurred on Oct 7, 2000, you would select 'Occurred 1st' for Concussion 1 and 'Occurred 2nd' for Concussion 2.

	Concussion Together 1st Time		**Concussion Together 2nd Time**	
	Occurred 1st	Occurred 2nd	Occurred 1st	Occurred 2nd
Concussion 1				
Concussion 2				
Concussion 3				
Concussion 4				
Concussion 5				

28) In order to obtain accurate data from all participants, please print your full name and contact information below. All personal information will only be used to contact participants for clarification of their answers if necessary. All information collected will be kept confidential. If additional information is not needed, or once all questions are answered, all participant contact information will be removed from the data.

Given First Name: _____

Last Name: _____

Preferred Email: _____

Rewrite Email: _____

Cell Phone with area code: _____

Thank you for completing this survey. Your responses will remain confidential and are greatly appreciated. Your name will be replaced with an ID number and your name will not be associated with your data in any of our publications or presentations.

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