CERVICAL SPINE MOTION AND COLLEGIATE ATHLETIC TRAINER CONFIDENCE DURING HELMET REMOVAL: A MULTI METHODS STUDY

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ABSTRACT

Rebecca F. Hersch: Cervical Spine Motion and Collegiate Athletic Trainer Confidence
During Helmet Removal: a Multi Methods Study
(Under the Direction of Meredith Petschauer)

Catastrophic cervical spine injuries are injures with damage to the upper-portion of the spinal cord. Current recommendations for athletic trainers treating these injuries are based on literature for American football equipment with limited research available for other sports. The purpose of this study was to evaluate the cervical spine motion during helmet removal for various helmet types and assess athletic trainer confidence for each helmet type. Spine motion was evaluated using three-dimensional motion capture, which provided real-time feedback about the cervical spine during helmet removal. Confidence was evaluated using a five-point Likert scale and collected throughout the data collection period. There was no significant difference between cervical spine motion across all helmet types. There was a significant difference for confidence while removing American football helmets compared to men's lacrosse and field hockey helmets. Athletic trainers are able to successfully complete tasks without training, but feel less confident in their execution.

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LIST OF ABBREVIATIONS

AE – Athletic Exposures

AED – Automated External Defibrillator

AMA – American Medical Association

ATC – Athletic Trainer Certified

BOC – Board of Certification

CAATE - Commission on Accreditation of Athletic Training Education

CPR – Cardiopulmonary Resuscitation

CT – Computerized Tomography

EAP – Emergency Action Plan

EHS – Exertional Heat Stroke

EMS – Emergency Medical Services

EMT – Emergency Medical Technician

HHS – Department of Health and Human Services

HRSA – Health Resources Services Administration

ISP – Injury Surveillance Program

KSI – Kory Stringer Institute

NAML –Neuromuscular Assessment Lab

NATA – National Athletic Trainers' Association

NCCSIR - National Center for Catastrophic Sport Injury Research

MVC – Motor Vehicle Collision

SRC – Sports Related Concussion

CHAPTER 1
INTRODUCTION

Background

There is no doubt that participation in athletics comes with the risk of injury. While the risk of sustaining a catastrophic injury while participating in athletics is relatively low, the potential for this injury is always present. Catastrophic injuries are defined by the National Center for Catastrophic Sport Injury Research (NCCSIR) as fatalities, injuries causing permanent disability, serious injuries (even if the athlete recovers fully), injuries causing temporary or transient paralysis, heat stroke due to exercise, or sudden cardiac arrest or severe cardiac disruption.[3] Among these life-threatening conditions are cervical spine injuries. These are defined as injuries inclusive of structural distortion of the spinal column with actual or potential damage to the spinal cord.[1] Cervical spine injuries can have serious long-term sequelae, such as paralysis and death.[1] Additionally, the diaphragm is innervated by the C3, C4, and C5 nerve roots. Damage to the upper portion of the spinal cord can lead to paralysis of the diaphragm and result in respiratory compromise.[2] It is imperative that athletes with respiratory compromise, resulting from a spinal cord injury or otherwise, be treated with airways and supplemental oxygen.[2] Further, athletes experiencing respiratory compromise can go into cardiac arrest, which requires cardiopulmonary resuscitation (CPR) and the use of an automated external defibrillator (AED).[2] Both respiratory and cardiac concerns need to be managed as quickly as possible to give the athlete the best chance of survival.

This life-saving care becomes difficult in athletes wearing shoulder pads and helmets because it impedes access to the airway and chest in these dire situations. According to the Korey Stringer Institute (KSI), the incidence of cervical spine injuries in athletics at the high school level is 0.07 per 100,000 athlete exposures (AE), and at the collegiate level 2.12 per 100,000 AE.[2] While previous research has documented that American football reports the highest number of cervical spine injuries occurring, when these numbers are standardized per 100,000 AE, ice hockey has the highest incidence rate of cervical spine injuries.[1] Nonetheless, an overwhelming amount of research is focused on the treatment of American football athletes with cervical spine injuries versus other equipment-intensive sports. This has resulted in an overall lack of literature related to the topic. Such information is necessary to guide a clinician's decision making process, and without it there is a potential impact on the level of care provided, which can put an athlete's health at risk.

Athletic trainers are healthcare professionals who work within athletic departments to evaluate, prevent, and rehabilitate orthopedic injuries. They work closely with the athletes throughout their season and are often present at practices and games to manage injuries immediately upon occurrence. Athletic trainers and members of the sports medicine staff are typically the first to respond during athletic events and are therefore responsible for the immediate care of a spine injured athlete. Due to this, athletic trainers spend much of their educational experiences practicing emergency scenarios to prepare for their future careers.

The Commission on Accreditation of Athletic Training Education (CAATE) sets the standards that all athletic training education programs must meet. According to CAATE, all athletic training students in accredited programs must have experience learning to remove athletic equipment.[4] However, the CAATE requirements are vague, and do not require athletic training education programs to teach the removal of different types of helmets. Since American football is more popular than ice hockey or men's lacrosse, athletic training programs may only teach students how to remove football helmets. As such, there is much variation between athletic training programs and the information that is taught to their students. The CAATE standards should be more specific to reduce variation in the information taught to athletic training students. The introduction of more standardized education standards would result in more competent athletic trainers and improve the quality of care provided to spine injured athletes.

A large part of an athletic trainer's clinical decision making is informed by the position statements of the National Athletic Trainers' Association (NATA). The current NATA position statement for the treatment of the spine injured athlete stresses maintaining in-line and neutral positioning of the cervical spine.[5] They recommend only removing the helmet in three scenarios: 1) the helmet does not fit adequately; 2) leaving the helmet in place will not allow for neutral position of the spine; 3) if the facemask cannot be removed.[5] In addition to these guidelines, they also always recommend the removal of the facemask to provide emergency airway management.[5] Previous literature has established that ice hockey and men's lacrosse helmets have a much looser fit when compared to American football helmets.[6,7] Therefore, it is speculated that men's lacrosse and ice hockey helmets do not adequately stabilize the head within the helmet, and thus the guidelines for managing cervical spine injuries should be different in these sports. Despite this, there is not a consensus for the emergency management of cervical spine injuries in men's lacrosse and ice hockey.

Research Questions and Hypothesis

Question 1: How much cervical spine motion occurs during emergency helmet removal of men's lacrosse, ice hockey, and field hockey helmets compared to American football helmets?

Hypothesis: There will be increased cervical spine motion during the removal of men's lacrosse, ice hockey, and field hockey helmets compared to American football helmets.

Question 2: How confident are Certified Athletic Trainers to safely remove helmets in men's lacrosse, ice hockey, and field hockey compared to American football?

Hypothesis: certified athletic trainers will feel less confident removing non-football helmets compared to football helmets.

CHAPTER 2
LITERATURE REVIEW

Introduction

A catastrophic cervical spine injury is defined as an injury inclusive of structural distortion of the cervical spinal column with actual or potential damage to the upper portion of the spinal cord.[1] Cervical spine injuries can have serious complications including paralysis and death.[1,2] Because of this, the proper handling of cervical spine trauma can be imperative to save an athlete's life. While it is true that most cervical spine injuries occur from motor vehicle collisions (MVC) or large falls, cervical spine injuries can also occur from sport participation, especially contact sports such as American football or ice hockey.

Previous research shows that athletic events are the fourth leading cause of all spinal cord injuries within the general population behind motor vehicle collisions, violence, and falls.[1] Sport-related events have been found to be the second leading cause of spinal cord injury in people under the age of 30, with the mean age of spinal cord injuries in sports related events being 24 years old.[1,8] This information is important, as most collegiate and high school athletes are under the age of 30, and would fall into this range. The NCCSIR has estimated that between the years of 2008-2019 there were 111 cervical spine injuries in collegiate and high school football, 5 cervical spine injuries in collegiate and high school ice hockey, and 4 cervical spine injuries and collegiate and high school men's lacrosse.[4] Although these numbers may seem comparatively low, any cervical spine injury can dramatically alter an athlete's life and adequate preparation should be taken by sports medicine professionals that care for these injuries to ensure positive outcomes.

Cervical spine injuries can have serious long-term sequelae such as paralysis and death. The diaphragm is innervated by the C3, C4, and C5 nerve roots. Damage to the upper portion of the spinal cord can lead to paralysis of the diaphragm and result in respiratory compromise.[2] It is imperative that athletes with respiratory compromise be treated with artificial airways and supplemental oxygen.[2] Additionally, athletes experiencing respiratory compromise can go into cardiac arrest, which CPR and the use of an AED.[2] Both respiratory and cardiac concerns need to be managed as quickly as possible to give the athlete the best chance of survival. With an understanding of the severity of cervical spine injuries, as well as their prevalence in high school and collegiate sports, it is imperative that they be cared for properly. As such, athletic trainers and other sports medicine professionals who care for athletes must know how to properly manage cervical spine injuries to prevent creating or worsening the injury.[1,2,6] Therefore, recommendations for treatment of cervical spine injuries put forward by the governing bodies of athletic trainers and sports medicine professionals must include the most up-to-date information.

Extensive research discussing the management of American football athletes who have suffered a cervical spine injury exists. However there is limited research about the topic as it pertains to other contact sports, including men’s and women’s lacrosse, ice hockey, and field hockey.[6,9] Though less common than in American football, the potential for occurrence of cervical spine injury still exists in these sports.[9] Additionally, much remains unknown related to cervical spine motion during equipment removal, as well as how much cervical spine motion is permissible to prevent iatrogenic injury.[1,6,10,11] Thus, the research that does exist is conflicting, with some recommending all equipment be left in place during prehospital care,[12] while others recommend removing some or all equipment during prehospital care.[5,9,13] It is imperative that there be a clear consensus for athletic trainers to follow when treating such dire situations.

Athletic Trainers

Athletic trainers are recognized by the American Medical Association (AMA), Health Resources Services Administration (HRSA), and the Department of Health and Human Services (HHS) as allied healthcare professionals.[14] In the athletic setting, they work closely with athletes to prevent, evaluate, and rehabilitate orthopedic injuries. Additionally, they are present at practices and games to assess and treat acute injuries as they happen. Due to their close relationship with athletic teams, athletic trainers are often the first to respond to athletic emergencies. As such, much of athletic training education is devoted to emergency care to teach prospective athletic trainers the best practices ensure athletes can have the best outcomes in these dire situations.

According to the NATA position statement regarding the management of cervical spine injuries, the clinician should provide manual cervical spine stabilization in a neutral position.[5] The management of such cervical spine injuries becomes more complicated in sports where athletes may be wearing helmets, shoulder pads, and other equipment, such as men's lacrosse, ice hockey, American football, and field hockey.[1,2,15] The helmets and shoulder pads can impede the ability to access the airway, provide chest compressions, and adequately hold cervical stabilization.[5,10] The NATA recommends helmet removal only in three certain scenarios: 1) the helmet does not fit adequately; 2) leaving the helmet in place will not allow for neutral position of the spine; 3) if the facemask cannot be removed.[5,15] Another source assessing ice hockey helmets recommends removing the helmet when other life threats such as cardiorespiratory compromise are present.[16] These recommendations are largely based on research on American football helmets, and may not be applicable for clinicians working with other equipment-intensive sports.

After athletic trainers have identified a cervical spine injury, they work closely with emergency medical technicians (EMTs) to continue proper care. Typically, athletic trainers will create an emergency action plan (EAP) that outlines the roles of each individual on the scene during an athletic emergency. In the NATA position statement about EAPs, they outline that all organizations that sponsor sports programs should have an EAP for each venue and is distributed to all medical personnel.[17] In addition to personnel roles, this document will also include information regarding communication guidelines and EMS field access.[17] They also recommend that the EAP be reviewed and practiced annually.[2,17] During this time, the athletic trainer and EMS will meet to discuss individual roles. This promotes teamwork and ensures a coordinated response to athletic emergencies. This becomes especially important when different healthcare providers are following different recommendations. In 2014, EMS changed their protocol and will no longer spine board all patients with a suspected spine injury.[18] Instead, they will use cervical collars as cervical immobilization and secure their patients to a stretcher.[18] Since its implementation in 2014, not all EMS institutions have enacted this protocol, but it has been documented that securing a patient to a stretcher does properly immobilize the patient.[18] As aforementioned, the NATA recommends that individuals with suspected cervical spine injuries be immobilized on a spine board.[5] This disparity in treatment protocols could lead to disagreements between healthcare professionals during treatment, which highlights the need for a single protocol that can be practiced by the healthcare team before these injuries occur.

Athletic Training Education

Athletic training education, like other health care professions involves both didactic and clinical components. Currently, for prospective athletic trainers to sit for the Board of Certification (BOC) examination, they must first graduate from an accredited undergraduate athletic training program. Beginning in 2022, athletic training is transitioning to an entry level master's model in an effort to give athletic trainer's higher salaries and advance their scope of practice. As such, prospective athletic trainers will then complete prerequisites during their undergraduate education, followed by reapplying and completing a 2-year master's degree program. It is assumed that athletic trainers in these programs will learn more advanced skills to further their clinical practice, such as phlebotomy and suturing. Despite this change, the CAATE will continue to remain the governing body responsible for setting the standards that all Athletic Training education programs must meet in order to be accredited.[19] Such standards outline the minimum competencies all athletic training students must achieve to take the BOC examination required to become a certified athletic trainer.[19] These competencies include Injury/illness prevention and wellness protection, clinical evaluation and diagnosis, immediate and emergency care, treatment and rehabilitation, and organization and professional health and well-being.

Within the current CAATE standards, which are valid from 2018-2021, Standard 70 includes that all athletic training students must be able to evaluate a myriad of acute conditions, of which "cervical spine compromise" is included.[19] However, emergency equipment removal is not addressed in this standard.[19] Further, Standard 86 of the current CAATE requirements states that athletic training students must know how to "select, fit, and remove athletic equipment."[19] This statement is vague and does not specify which equipment needs to be taught to students. Importantly, the CAATE standards as they are written do not require athletic training programs to teach emergency helmet removal in any capacity. This becomes problematic, as programs can gain accreditation and educate students to be eligible for their certification exam without adequately preparing their students to manage cervical spine injuries in equipment-intensive sports such as American Football, men's lacrosse, or men's ice hockey.

If athletic training programs choose to teach emergency helmet removal at all, it is likely that they will only teach their students to remove American football helmets because football has the highest number of cervical spine injuries and has higher participation than men's lacrosse or ice hockey. Furthermore, athletic training education programs at smaller universities may not have football, lacrosse, or ice hockey teams for their students to practice helmet removal in the clinical setting. Additionally, it is difficult for programs to replicate a true cervical spine experience, which can result in discrepancies with the skills and confidence of prospective athletic trainers. It is currently unknown what each CAATE accredited program does to meet CAATE standards. It is also unknown what percentage of CAATE accredited programs teach athletic training students about the emergency removal helmets in American football or equipment-intensive sports. This creates disparities among different athletic training education programs. Some students will become certified and licensed athletic trainers without having any prior education in helmet removal.

American Football

American football has a large number of participants across numerous settings. It is estimated that 1.8 million athletes participate in this type of football each year.[1] Due to its high numbers of participation, it is not surprising that American football also has the highest number of cervical spine injuries, though ice hockey was found to have the highest rate of cervical spine injuries.[1] Football involves high velocity running and tackling, which makes it a high risk sport for cervical spine injury. It is estimated that 69% of catastrophic cervical spine injuries that occurred during football were the result of tackling.[1] Despite these numbers, the rate of catastrophic cervical spinal injury in football from 1979-2004 is low. These rates were found to be 0.52 per 100,000 athlete exposures (AE) in high school football, and 1.55 per 100,000 AE in collegiate football.[1,4] A more recent study from 2009-2014 used data from the NCAA injury surveillance program (ISP) found that the incidence of cervical fracture was 0.04 per 10,000 AE.[20] This study did not specifically report the incidence of catastrophic spinal injury; however, based on the previously stated definition, cervical fractures would be considered a catastrophic cervical spine injury. Between the two studies, there is a slight decrease in the incidence of cervical spine injuries in American football, despite implementation of targeting rules to reduce helmet-to-helmet contact. The 2009-2014 article reported on all cervical spine injuries including non-life threatening injuries such as brachial plexus injuries (stingers) and neck sprains, which were found to be much more common than cervical fractures.[20] In contrast, a 2002 study found the incidence of traumatic quadriplegia was 0.33 per 100,000 AE in high school football and 1.33 per 100,000 AE in college football.[1,4] There has been legislation in American football to prevent dangerous types of tackling such as "spear-heading" that are more likely to result in cervical spine injuries. Therefore, the incidence of long-term sequelae following a cervical spine injury is still present, and therefore it is still imperative that all cervical trauma be treated with caution to mitigate bad outcomes.

Currently, there exists more research discussing best practices when treating a spine injured American football athletes compared to other equipment-intensive sports. It has been found that American football helmets have a tighter fit when compared to men's lacrosse and ice hockey helmets, and therefore are better at stabilizing the head within the helmet thereby reducing cervical spine motion.[6,9] Therefore, it is hypothesized that it may be more appropriate to remove only the facemask of American football helmets, but to leave the helmet in as it will adequately stabilize the cervical spine. This may not be the case in other equipment-intensive sports with helmets that do not fit as tightly.

Men's Lacrosse

Men's lacrosse is a less popular sport than American football, but participation in lacrosse has been steadily growing. A 2018 report from USA Lacrosse estimates 186,000 athletes participate at the high school level, and 25,000 participate at the collegiate level.[21] The incidence of catastrophic cervical spine injury in men's lacrosse is unknown, but assumed to be rare. However, simply because cervical spine injury is rare, does not mean that there is no need for further research related to this topic. Athletic trainers are present at all men's lacrosse practices and games and would be the first to respond to potential cervical spine injuries as they occur. As such, it is imperative that athletic trainers be trained in appropriate helmet removal techniques to provide the best care to these athletes.

All men's lacrosse athletes including the goalkeeper wear helmets and shoulder pads. There are many different styles of men's lacrosse helmets, and as a result there exists no standard method of helmet removal for the spine injured lacrosse athlete. Unlike American football facemasks, which have four screws and can be removed with ease, the men's lacrosse facemask is more complicated and often includes a chin piece that may or may not need to be removed separate from the facemask. The disparities in helmet designs between men's lacrosse and American football further supports the need for more research on this topic.

Previous research has found that men's lacrosse helmets, even when properly fit, allow for more motion of the head and neck than football helmets.[6,9] This suggests that immobilizing the athlete in their equipment is not effective in minimizing cervical spine motion.[9] Since it is currently unknown how much cervical spine motion is permissible to prevent further injury, limiting cervical spine motion becomes imperative to treatment. However, previous research by Wanger et al.[12] found that although there is more cervical spine motion of the neck within the helmet in men's lacrosse helmets compared to American football, the amount of motion was not statistically significant when compared to controls that were not wearing helmets.[12] As such, these authors suggest that helmets should be left on during prehospital care of cervical spine injuries.[6] However, the literature remains split on the topic of removing the equipment or not in lacrosse athletes. Higgins et al.[22] found that there was no significant change in the space available for the spinal cord when lacrosse athletes were immobilized without their helmet with shoulder pads in place.[22] Not only does this differ from the findings of other research groups, it also further challenges the "all-or-none" approach outlined the NATA position statement, where it is recommend that either all or none of the equipment be removed rather than just some pieces.[5] Higgins et al[22] also found that there was a change in the cervicothoracic angle when models were immobilized on a spine board in shoulder pads without a helmet.[22] These findings were further corroborated by a different study that found cervical spine motion was greater when athletes were immobilized on a spine board in full equipment than without any equipment.[11] This would suggest that removing equipment should be recommended for men's lacrosse athletes.[11] The current research does not reach a clear consensus regarding whether or not to remove men's lacrosse helmets, therefore leaving athletic trainers to make emergency decisions based on limited research, and risking the health and safety of athletes who sustain cervical spine injuries.

Other studies have assessed just removing the facemask from the lacrosse helmet as opposed to removal of the helmet in its entirety, which is consistent with the recommendations provided by the NATA position statement, which suggests removing the facemask to allow for uninhibited airway access.[5] Among the literature, one previous study assessed facemask removal using different tools on four different styles of lacrosse helmets.[23] Authors found that a cordless screw driver was the most efficient tool for facemask removal when compared to a facemask extractor, a trainer's angel, and a pruner tool. When comparing between helmet models, the facemask on the Cascade CPX helmet was able to be removed faster than the facemasks on Brine's Triumph XP helmet, Warrior's Venom helmet, Cascade's Pro 7 helmet, and Riddell's Revolution lacrosse helmet.[23] This research may give insight to athletic trainers about which tools are most efficient, as well as which helmets may be the safest for men's lacrosse athletes suffering from cervical spine injuries. However, there is still a need for a clear consensus for practicing athletic trainers to follow when managing cervical spine injuries in this population.

Women's Lacrosse

To the best of our knowledge, there are currently no published studies that discuss the treatment of spine injured athletes in women's lacrosse. The NCCSIR did not report any catastrophic cervical spine injuries in women's lacrosse from 2008-2019.[4] Unlike men's lacrosse, women's lacrosse is not considered a contact sport, however, according to the NCAA epidemiology study of women's lacrosse injuries from 1988-2004, most women's lacrosse injuries occur from contact between players or between sticks and players.[24] The NCAA reported the most common injuries in women's lacrosse were ankle sprains, knee sprains, and concussions.[24] Though, contact may not be as prevalent as in men's lacrosse, the risk for catastrophic spinal injury still exists. The goalkeepers in women's lacrosse are the only players to wear helmets and full protective gear. These helmets could complicate the management of a cervical spine injury in athletes playing this position. While the risk of an equipment laden athlete sustaining a cervical spine injury in women's lacrosse is lower than men's lacrosse, this does not mean that women's lacrosse athletic trainer should not adequately prepare for these injuries. Like men's lacrosse, there are many different styles of women's lacrosse helmets, and the type used may vary based on the athlete's own preference, however, it is common for women's lacrosse goal keepers to wear men's lacrosse helmets, so many of the same recommendations can be applied. As previously stated, the risk of cervical spine injury in women's lacrosse is low, but women's lacrosse athletic trainers should still familiarize themselves with their individual goalkeeper's helmet.

Ice Hockey

Men's Ice Hockey

Men's ice hockey is commonly cited in the current literature for having high numbers of cervical spine injuries. However, these numbers have declined since the implementation of rules to eliminate checking players from behind.[1] Though the number of cervical spine injuries is highest in American football, the rate of catastrophic injury per 100,000 AE is higher in men's ice hockey than American football.[1] Additionally, ice hockey cervical spinal injuries have more commonly resulted in long-term deficits when compare to those suffered in American football.[1] In 2004, Banerjee et al.[1] reported that the annual incidence of spinal cord damage with paralysis was at least three times higher in men's ice hockey than American football.[1] According to the NCCSIR, most cervical spine injuries in ice hockey occur from contact between players moving at high velocities, and from players contacting the boards surrounding the rink.[4] It has also been reported that checking an opponent from behind is a common mechanism for cervical spine fractures in ice hockey.[1] Rules that aim to decrease checking from behind and checking an opponent without the puck have been implemented, which have successfully decreased the incidence of cervical spine injuries since their implementation.[1] Despite these rules, the risk for cervical spine injury is still high in ice hockey due to the high velocity player-to-player contact that occurs throughout the game.

Similar to men's lacrosse, there are many different styles of ice hockey helmets, thus making it difficult to determine a single procedure for helmet removal should it be needed. Additionally, the goalkeeper in ice hockey typically wears a different style helmet than the other field players, further complicating the research into helmet removal in this sport, as recommendations may vary between field players and the goalkeeper. Similar to lacrosse helmets, previous research has reported that ice hockey helmets do not stabilize the head within the helmet as well as American football helmets.[6,13,16] There is research supporting that significant changes in cervical spine alignment occurs when the athletes are immobilized in their shoulder pads without a helmet.[13,16] This is again consistent with the "all-or-none" approach outlined in the NATA position statement,[5] however indicates that current research on the topic is still inconclusive. As such, some recommendations indicate keeping the helmet and shoulder pads in place during prehospital care provides the best outcomes,[12] while others recommendations suggest removing all equipment.[17] That said, it is recommended to remove equipment if other threats to life are present.[16] Similar to men's lacrosse, there is still a need for a clear consensus for practicing athletic trainers to follow when managing cervical spine injuries in this population.

Women's Ice Hockey

Women's ice hockey operates like men's ice hockey; however, the rules do not allow for formal body checking. Regardless, according to an NCAA surveillance study, 50% of all injuries resulted from person-to-person contact.[25] Women's ice hockey is a newer sport to the NCAA, with only 4 years of surveillance data available.[25] In those four years, it has been found that the lower extremity, upper extremity, and head and neck were the most commonly injured areas in women's ice hockey.[25] More specifically, concussions, acromioclavicular joint injury, and knee ligament injury were the most common specific injuries encountered within the sport.[25] To the best of our knowledge, there are no currently published studies that discuss the treatment of spine injured athletes in women's ice hockey. Like men's ice hockey, all athletes are required to wear helmets, and the goalkeeper wears a different helmet than the rest of the athletes. There are many different styles of women's ice hockey helmets, and the type used may vary based on the athlete's own preference, however, it is common for women's ice hockey helmets to be to be the same as men's ice hockey helmets. As such, many of the same recommendations for men's ice hockey may be applicable here. However, the literature is still lacking in regard to the management of spine injured ice hockey athletes an there is a need for a clear consensus for practicing athletic trainers to follow.

Field Hockey

The NCAA estimates that over 6,000 athletes competed in field hockey at the collegiate level, and 60,000 athletes competed at the high school level.[26,27] Despite field hockey involving fast-moving balls and sticks, there is minimal protective equipment except for the goalie who wears a helmet, knee and foot pads, a chest protector, and shoulder pads. Similar to women's lacrosse, field hockey is not considered a contact sport, yet the risk for catastrophic injury is still present albeit likely less than in other sports. According to the NCAA, the most common injuries in field hockey are to the head and face and to the upper leg and hip. Such injuries most commonly occur from contact with the ball, contact with the ground, and contact with another person.[27] To the best of our knowledge, there are no currently published studies that discuss the treatment of spine injured athletes in field hockey. Only the goalkeeper wears a helmet in this sport. There are many different styles of helmets that field hockey goalies wear. The type used may vary based on the athlete's own preference, however, it is common for field hockey goalies to wear helmets that are structured similar ice hockey goalie helmets, so many of the same recommendations can be used.

Helmet Consensus/Removal Recommendations

The current recommendations for athletic trainers' management of spine injured athletes are based off the 2009 NATA position statement, which only recommends removing the helmet if it is not properly fitted to the athlete. This recommendation is made based on the findings that poorly fitted helmets allow for considerable cervical spine motion, increasing the risk for further injury during care.[5] The NATA additionally outlines best-practices for helmet removal as an "all-or-none" approach, meaning the helmet and shoulder pads should both be removed, or neither should be removed.[5] Outside of helmet removal, the NATA recommends that the facemasks always be removed to allow for emergency airway access.[5] These recommendations are largely based on the management of American football athletes, and as such there are no specific recommendations for equipment laden athletes competing in other sports. A 2020 systematic review of the prehospital care of spine injured athletes recommends the removal of the facemask of the helmet because this allows for less cervical spine motion than total helmet removal and gives access to the airway.[10] Despite these recommendations, there is still a lack of information for athletic trainers managing non-football athletics to follow, should their athletes suffer from a cervical spine injury that requires a decision on helmet removal to be made.

Athletic Trainer Confidence

To the best of our knowledge there are no studies assessing the confidence of athletic trainers to remove athletic equipment in athletes with a potential cervical spine injury. That said, previous literature assessing other aspects of athletic training is available. One previous study uses surveys to assess the self-efficacy of athletic trainers to assess sports related concussions (SRC).[28] They defined self-efficacy as the "beliefs in one's capabilities to organize and execute the courses of action required to manage prospective situations."[28] This study used a survey to assess self-efficacy by asking their participants to rate on a scale of 0-100 how comfortable they felt with the assessment and management of SRCs.[28] Their methods could be applicable to this study to assess ATC confidence when removing different types of helmets. Additionally, this study will measure cervical spine motion, so the ATC perceived confidence can be compared to their actual cervical spine motion. A different study used a survey and Likert scale to assess the current practices of athletic trainers to assess and manage exertional heat stroke (EHS).[29] This study asked specific questions based on the NATA position statement on heat illness to assess which recommendations athletic trainers are using in their practice.[29] The methods in this study show a validated method to assess the athletic trainer's current practices to manage EHS. Similar questions will be included in this study to assess which practices regarding the preparation for and management of cervical spine injuries are being used by practicing athletic trainers.

Techniques for Measuring Cervical Spine Motion During Helmet Removal

The available literature provides various techniques to measure cervical spine motion during helmet removal in American football, men's lacrosse, and ice hockey. However, there is a lack of information regarding the amount of permissible cervical spine motion to prevent injury, thus it is imperative that cervical spine motion be limited as much as possible during emergency equipment removal. Helmet removal techniques resulting in the smallest amount of cervical spine motion would be most beneficial for practicing athletic trainers to follow. Due to the severity of cervical spine injuries, the measurement techniques that accurately represent cervical spine motion are most beneficial. The most common methods to measure cervical spine motion include three-dimensional motion capture, radiographic imaging, and cadaveric models.

Three-Dimensional Motion Capture

Three-dimensional motion capture is one way to measure cervical spine motion. It includes the ability to assess real-time cervical spine motion during helmet removal. Therefore, it can account for cervical spine motion throughout the entire helmet removal process instead of assessing the spine position before and after helmet removal. Previous studies have utilized this three-dimensional motion capture to assess cervical spine motion during various activity. Swartz et al.[7,8] used this technique to measure head motion during helmet removal, attaching markers to a custom-made bite marker in the model's mouth.[7,8] Similarly, Mihalik et al.[13] used a MotionMonitor (Innovative Sports Training, Chicago, IL) 3D motion capture system software to obtain kinematic data during a prone log roll procedure in ice hockey.[13] In this study, sensors were placed on a custom mouthpiece, on the proximal sternum, and on the top of the helmet to measure head and neck motion during the movement.[13] Additionally, Petschauer et al.[9] measured cervical spine motion in athletes wearing the Cascade CPX men's lacrosse helmet when secured to a spine board. Electromagnetic motion analysis with a Motion Star system (Ascension Technology Corporation, Burlington, VT), was used, with a sensor placed in three locations on the head: 1)on the top of the helmet 2) on the manubrium, and 3) attached to a mouthpiece.[9] One strength of these methods is the ability to measure range of motion in real-time as the movements occur. This can be useful to measure the motion that occurs during helmet or facemask removal, instead of looking at cervical spine position before and after their removal. One limitation of this method is that it is expensive and often the sensors can experience interference from metals such as the facemask of the helmet, which can cause issues when collecting data on helmet and facemask removal.

Radiographic Imaging

Radiographic imaging is also considered an acceptable method to measure cervical spine range of motion. Unlike other methods, this technique can assess for spinal cord space using MRI imaging, which can be useful to determine the likelihood of spinal cord injury with the neck in certain positions. Higgins et al.[22] previously used MRI imaging to assess the space available for the spinal cord and the cervicothoracic angle in athletes wearing both helmet and shoulder pads, wearing only a helmet, and those not wearing any equipment.[22] Sherbondy et al.[11] used computed tomography (CT) in models while wearing helmet and shoulder pads, while only wearing their helmet, and without any equipment.[11] Decoster et al. assessed cervical alignment using x-ray analysis before and after the removal of American football equipment to determine any significant changes in cervical spine alignment.[15] One advantage to this study is that the measurements are very specific because they allow for measurements at the vertebral level instead of looking at neck position. Additionally, such studies with imaging allow for visualization of the spinal cord in potentially compromising positions to more adequately assess the risks associated with such positions. Some limitations of this method include that it is expensive, and that some types of imaging may model’s the patients to levels of radiation.

Cadaveric Models

Since much is unknown about the amount of cervical spine motion is permissible without causing further injury, cadaver models can offer a way to ethically measure cervical spine motion in emergency conditions. Additionally, alterations can be made in the cervical spine to simulate injury. Conrad et al. used five cadavers with artificially created C5-C6 instability and compared cervical spine motion during prone log roll techniques in cadavers wearing three different levels of equipment: football helmet and shoulder pads, cervical collar, and no equipment present.[30] This study also used an electronic motion-analysis device, LIBERTY (Polhemus Inc, Colchester, VT) to detect cervical motion in the three anatomical planes.[30] Another cadaveric study was completed by Donaldson et al. assessed cervical spine position in cadavers with artificially created C1-C2 instability or C5-C6 instability.[31] The cadavers were wearing helmet and shoulder pads, and cervical spine motion measured using a fluoroscope as the helmet and shoulder pads were removed.[31] Cadaveric models are useful to assess the cervical spine motion and positioning when potential injury is present, and such methods present an ethical way to recreate injuries that may be seen in the clinical setting. However, cadaveric models fail to reflect cervical spine motion in live humans, which can make it difficult to draw conclusions for clinical applications. Additionally, this method of measuring cervical spine motion can be very expensive and may not be feasible for most research studies.

The proposed study will utilize three-dimensional motion capture to assess cervical spine motion because it is the most cost effective method to monitor cervical spine motion when compared to radiography and cadaver models. Furthermore, three-dimensional motion capture provides data for real-time cervical spine motion during helmet removal instead of assessing neck position before and after helmet removal. Ultimately, such methods which will be more useful and less time consuming since this study also assesses ATC confidence.

Conclusion

Within the current body of literature, few studies assess cervical spine motion in ice hockey and men's lacrosse. Those that do exist fail to provide a clear consensus for practicing athletic trainers to follow when working with these athletes. This lack of literature leaves athletic trainers working with these sports to rely on the NATA position statements, which are developed largely from research on American football helmets. Many athletic trainers working with these sports will have to develop their own individual policies for the management of cervical spine injuries.

Additionally, there is a lack of literature available to discern what information about helmet removal is taught to athletic training students prior entering into clinical settings. It would be useful to know what percent of athletic training programs teach helmet removal since some schools may not have equipment-intensive sports, and therefore may not teach this information to their students. Furthermore, to the best of our knowledge, there are no current studies that assess confidence levels of the athletic trainer during emergency helmet removal in American football, men's lacrosse, ice hockey, or field hockey.

As such, the first aim of this study is to assess cervical spine motion using three-dimensional motion capture during emergency helmet removal in men's lacrosse and ice hockey compared to American football helmets. Three-dimensional motion capture will be used because it is the most cost-effective method to monitor cervical spine motion when compared to radiography and cadaver models. Additionally, three-dimensional motion capture can provide data for real-time cervical spine motion during helmet removal instead of assessing neck position before and after helmet removal.

The second study aim will seek to assess the confidence level of athletic trainers during the emergency helmet removal of men's lacrosse, ice hockey, and field hockey helmets compared to American football helmets using a Likert scale. It is hypothesized that there will be greater cervical spine motion during the removal of men's lacrosse, ice hockey, and field hockey helmets compared to football helmets. Additionally, it is hypothesized that athletic trainers will feel less confident removing men's lacrosse, ice hockey, and field hockey helmets compared to American football helmets. The goal of this study is to identify the need for more uniform athletic training education prior to athletic trainers entering the field as well as assess the cervical spine motion that occurs during emergency helmet removal in men's lacrosse, ice hockey, and field hockey.

CHAPTER 3
METHODS

Study Design

A cross sectional study design was used to explore practicing ATC confidence in helmet removal. Each participant attended a single half-hour long data collection session which included a helmet removal portion and an online questionnaire. The participants started by answering background questions on the online questionnaire, which contained items about their demographic information, education background, and clinical practice experience. During the helmet removal portion each participant removed four different helmets three times each in a random order. After completing all trials of one helmet, subjects answered a question asking about their confidence while removing that type of helmet. After removing all the helmets, the participants completed additional questions, which contained items about their overall confidence and previous clinical and educaitonal experiences related to helmet removal.

Participants

A convenience sample of 16 ATCs was used for this study. Participants were recritued vai email, with emails of ATCs local to the Chapel Hill, North Carolina area found using staff directories from nearby high schools and universities. A recruitment email was sent to each participant, with biweekly follow up emails as needed during an eight-week recruitment period. A maximum of five emails was sent to each potential participant (the initial email and four follow ups). The email included a link to an online recruitment survey (Qualtrics Labs, Provo, UT) for scheduling purposes.

Individuals were eligible for participation in this study if: 1) they were ATCs certified and licensed to practice in the state of North Carolina, 2) could travel to Chapel Hill once to participate in study activities, 3) were currently practicing in a setting that requires them to provide coverage at athletic events (e.g. at a high school, college or university, or do so on a per diem basis), and 4) have worked as an athletic trainer with American football within the last five years. Individuals were excluded from study participation if: 1) they were not a certified ATC licensed in the state of North Carolina, 2) had an upper extremity injury that limits their ability to remove a helmet of any kind, 3) were unable to travel to Chapel Hill once to participate in study activities, or 4) had not worked as an athletic trainer with American football during the last five years. Participants were not provided with any incentives or compensation for their participation in this study. Each participant provided written informed consent prior to participation in any study activities. All methods were approved by the Institutional Review Board at the University of North Carolina at Chapel Hill.

Procedures

General Overview

Each participant reported to the Neuromuscular Assessment Lab (NAML) on the campus of the University of North Carolina at Chapel Hill for a single data collection session. Each participant removed four helmets from a model in a randomized order: a men's lacrosse helmet, an ice hockey helmet, a field hockey helmet, and an American football helmet. The helmets used were: Riddell Revolution (BRG Sports, Des Plaines, IL) for American football, Rival men's lacrosse helmet (STX, Baltimore, MD) for men's lacrosse, CCM ice hockey helmet (CCM Hockey, Montreal, Quebec, Canada) for ice hockey, and OBO ROBO PE field hockey helmet (Palmerston North, New Zealand) for field hockey. All helmets were chosen due to popularity and frequency with which they are worn in each of their respective sports. The order of helmet removal was randomized using a random number generator from 1-4 for each participant. This was done to reduce any learning effects that may result in confounding data.

Prior to the helmet removal portion, each participant completed the initial portion of the survey, which asked questions about their demographic and educational background. Following this, the survey then prompted them to hand the computer to a research assistant once they had completed the necessary information. The research assistant then entered the pre-determined order of the helmets and the computer was eventually returned to the subject to answer further questions following the removal of each helmet. To begin the helmet removal portion of the study, the subject was read a short scenario that ultimately required the removal of the model's helmet. Each participant was given the opportunity to ask any clarifying questions prior to removing each helmet. Participants were not allowed to ask any questions during the removal process. Due to limited helmet availability and the need for standardization, participants were instructed to remove the helmet without removing the facemask or padding. Participants did not have access to any tools or cutting devices (e.g. cordless screw drivers, Facemask extractors, or Trainer's Angels).

The participants removed each helmet three times based on their own knowledge and skills. The average total motion for all three trials, the average motion in all three planes (sagittal, transverse, and frontal), the maximum motion in all three planes, and the average time for helmet removal was calculated. Standardization was maintained by using the same model for each participant. Additionally, the model was always positioned in a supine manner with their head and neck in a neutral position. The model was instructed not to interact with the participants while they are removing the helmets. To further maintain standardization, the principal investigator (PI) held cervical spine stabilization for each trial. The PI is a certified and licensed athletic trainer, as well as a licensed EMT, with previous experience in holding cervical stabilization.

After all three removal trials for each helmet, the subject answered one question which asked about their confidence level while removing that type of helmet prior to proceeding to removal of the next helmet type. After removing all four helmet types, the participants completed the remaining portions of the of the survey, which asked additional questions about their confidence level while removing all helmets using a Likert scale.

Helmet Removal

The helmet removal portion of this study aimed to measure cervical spine motion during helmet removal. A Flock of Birds (Ascension Technologies, Inc. Burlington, VT) electromagnetic motion analysis system controlled by MotionMonitor software (Innovative Sports Training, Inc. Chicago, Illinois) was utilized to capture the motion between the head and the thorax. For the purposes of this study, this was deemed cervical spine motion. This electromagnetic tracking system is accurate within 1.8 mm for linear displacements and 0.5 degrees for angular displacements.[13,32] Kinematic data was sampled at 100 Hz and filtered with a low-pass, zero-lag, Butterworth filter at 10 Hz. These parameters are consistent with what has been used in previous literature.[32] Sensors were attached to the model using tape at on the bridge of nose and the sternum (Figure 1).

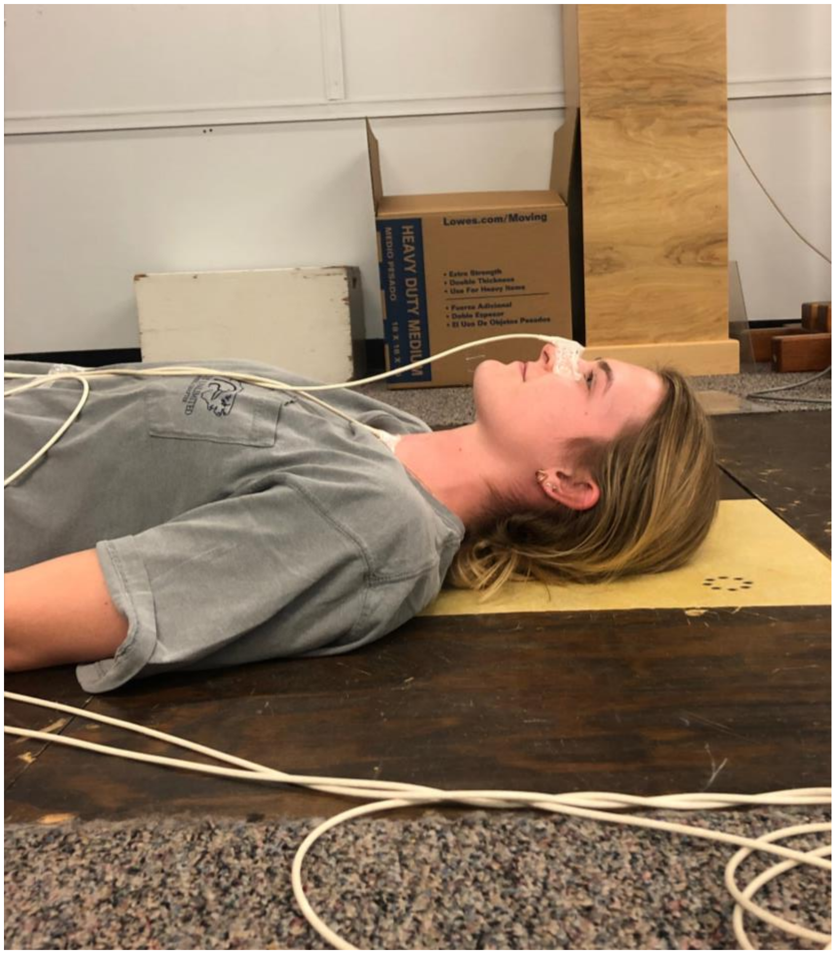


Figure 1 – Model positioning with sensors affixed to nose and sternum

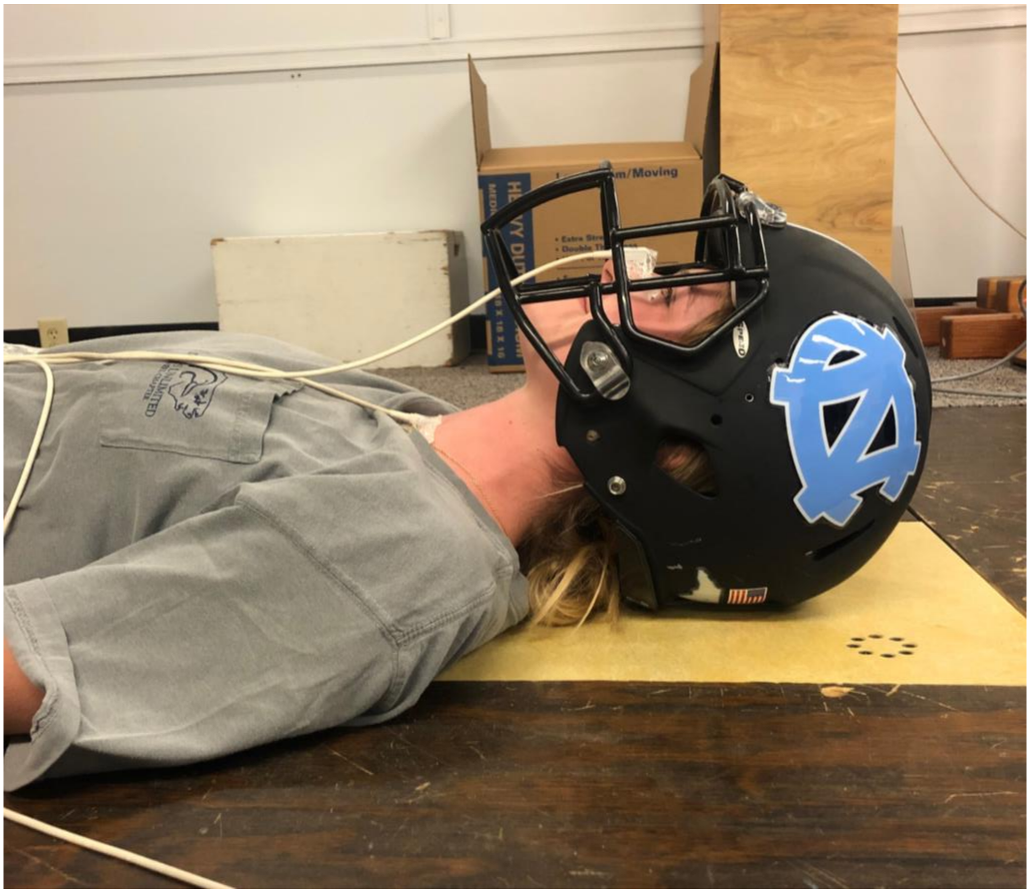


Figure 2 – Model positioning with sensors affixed to
nose and sternum with helmet to be removed

These sensor positions allowed for real-time feedback about head motion relative to the thorax to be gained, allowing for an understaning of the motion occurring within the cervical spine. These sensor placements were chosen due to their distance from external disruptions from equipment movement (i.e., being bumped by the helemet during the removal process) and minimal soft tissue structures underlying leding to excess motion being recorded. Sensors were affixed using double-sided tape to ensure they did not move independently of the model and thus influence the data. Following sensor placement, the sensors were digitized using the occiput, the C7/T1 joint space, and the T12/L1 joint space as anatomical landmarks to orient the system axes. Three-dimensional motion capture has previously been used by several other researchers to measure cervical spine motion during helmet removal. Although the sensor placement for this study varied from such previous studies, the procedures followed were comparable to Mihalik et al,[13] Swartz et al.[8] Petschauer et al.[9], and Toler et al.[32]

To mitigate any learning effects during the helmet removal process, a random number generator from 1-4 was used to randomize the order in which each participant removed the helmets. Once the order was determined, research assistants prepared the model with the first helmet. Each helmet had been previously fit to the model for the per the manufacturer's standards prior to beginning data collection, yet the fit of each helmet was checked by the research assistant prior to each trial.

The participant was then read a scenario (Appendix A) explaining their athlete experienced a mechanism for a cervical spine injury during play. The ATC has already completed an evaluation and decided to remove their helmet. The ATC was given the instructions not to remove the facemask as they remove the helmet, and they were not permitted access to any equipment to remove the facemask or side padding of the helmet. After all instructions are read, the ATC was given time to ask any clarifying questions. Once ready, the principal investigator held manual stabilization of the cervical spine and the research assistant began the data collection period. Data collection began when the ATC first touched the helmet and and eacha trial ended when the helmet cleared the head.

After removing the helmet three times, the ATC answered a single question on the survey that asked how confident they felt while removing that helmet type. As the ATC completed the survey, the research assistants prepared the model with the next helmet type to be removed. Each successive trial proceed the same as the first. The participants were made aware that they were timed during each trial and the timer began once they first touched the helmet and ended when the helmet completely cleared the head.

Survey Instrument

Each participant completed an online survey instrument that aimed to collect information about their demographic information, athletic training education, and their experience and comfort removing various types of helmets (Appendix 1). The portion of the survey instrument regarding demographic information and educational history was developed by the primary investigator. While there are no current studies assessing the confidence of athletic trainers to remove various helmets, Savage et al. [28] has previously used surveys to assess self-efficacy of ATCs. Self-efficacy provides an estimate of how a person perceives their ability to complete a task. The survey questions about confidence in this study were developed and constructed in a similar manner, and aimed to assess how well athletic trainers felt they could remove different helmet types outside of the data collection period. The participants were asked to rate the helmets that they felt most and least comfortable removing. They also rated how successful they felt they were at removing helmets during the data collection period on a 0 to 100 scale. In addition to self efficacy, ATC perceived confidence in removing each helmet was assessed with a 5-point Likert scale after removing all four helmets. Likert scales have been widely used in literature to assess attitudes or opinions. While it has not been used to measure ATC confidence in removing various helmet types, it has been used to assess ATC perceptions to other emergent conditions such as exertional heat stroke.[29]

Prior to beginning helmet removal, the subject completed the demographic and educational portions of the survey instrument. The first question gave each subject a specialized ID code, which corresponds to their Flock of Birds data. At the conclusion of three trials of a helmet type, the participant was given the survey and instructed to answer one question, which asked how confident they felt while removing that type of helmet. This proceeded for all four types of helmets, and they completed additional questions which asked more specific questions regarding their past experience with cervical spine injuries. Once the ATC had finished the survey, they completed their participation in the study .

Data Analysis

Aim 1- Cervical Spine Motion

Data for the first aim was analyzed by calculating Euler angles to quantify the movement of the head relative to the thorax. The order of the Euler angle sequence was: sagittal (flexion and extension, y-axis), transverse (right and left rotation, z-axis), and frontal (right and left lateral flexion, x-axis). Positive motions were flexion, left rotation, and right lateral flexion; negative motions were extension, right rotation, and left lateral flexion. The raw data was graphed and assessed for any large and rapid changes motion that were present in each plane, which were indicative of a sensor being hit during the removal process. The data was cleaned by removing the errant data and replacing it with the averages of the last five data points before and after the sensor was hit to smooth the data to reflect true motion during the removal process. Data was initially reduced using MATLAB data processing system (MathWorks, Natick, MA). A Simpson integration was programmed to find the total cervical spine motion by rectifying the data with respect to the starting position of the head and helmet prior to the trial beginning and then summing the area under the curve to determine resultant cervical spine movement for each plane of motion. This resulting motion was normalized to time by dividing each number by the time taken for that specific trial. Maximum cervical spine movement was found by rectifying the data with respect to the starting position of the head and neck prior to beginning the trial and then using the maximum value in each plane. The mean total and maximum motion for each plane , each trial, and each helmet type was calculated for every subject. The resulting motion in each plane was evaluated for outliers. Outliers were defined as data points that were more than three standard deviations above the mean. Since three trials were recorded, outliers were able to be removed without affecting the overall data. If outliers were removed from one condition, the remaining two trials were averaged before assessing the mean motion for each subject in each plane. Standard deviations were also calculated for each plane of motion and each helmet type. These data analysis methods are consistent with those used in previous literature.[32] Data was reviewed for normality and descriptive statistics were calculated, which included means and standard deviations. Repeated measures ANOVAs were then utilized to compare group differences between helmet types.

Aim 2- ATC Confidence

Data for the second aim was processed by using the survey responses. The 5-point Likert scale responses were standardized to their numbers, with 5 indicating the most confidence and 1 indicating least confident. Means and standard deviations were compared between helmet types, and following this ANOVAs were used to determine statistically significant differences in ATC confidence when removing the different helmet types. Additional information that could have affected ATC confidence was also collected, including: number of years as a practicing ATC with American football, number of years working men's lacrosse, ice hockey, and/or field hockey, previous experience treating cervical spine injuries. Additional questions also asked about how ATCs were taught to remove helmets during their initial athletic training education, and how long their initial education program spent educating them on proper ways to remove helmets. Understanding these variables allowed for better accounting of further information that could affect ATC confidence.

Power Analysis

Existing studies that have utilized three-dimensional motion capture to analyze cervical spine motion during helmet removal have used 18-32 participants. [9,13,23]An *a priori* power analysis was conducted using pilot data for this study. This power analysis was completed for each plane of motion (sagittal, frontal, and transverse) using means and standard deviations. Calculations were completed using G*Power (UCLA, Los Angeles). These three power analyses indicated we needed samples of 15, 12, and 15 participants respectively to provide a power of 0.80 (80%) with $\alpha = 0.05$ to correlate helmet type with amount of cervical spine motion during helmet removal. As such, we included 16 participants.

Impacts

These methods serve to meet the aim of establishing ATC confidence in removal of men's lacrosse, ice hockey, and field hockey helmets when compared to American football helmets. It will also assess the cervical spine motion present while removing these types of helmets using three-dimensional motion capture. To the best of our knowledge there is currently no available literature assessing ATC confidence during helmet removal. The findings from this study aim to identify a gap in athletic training education and increase the safety of athletes participating in equipment intensive sports.

CHAPTER 4
RESULTS

Participant Characteristics

A total of 16 ATCs were included as subjects in this study. All subjects reported having worked American football as an ATC within the last five years of practice, and are currently practicing athletic training in the collegiate setting (NCAA, JuCo, or NAIA). Overall, subjects were on average 27 ± 4.35 years of age, with one subject who declined to provide this information. Ten subjects identified as male, while 6 identified as female. Overall, the subjects had been practicing as an ATC for an average of 5 ± 4.11 years. Group demographics are presented in Table 1. Five subjects had experience working with men's lacrosse, 4 subjects had experience working with ice hockey, and 5 subjects had experience working with field hockey. All sport specific work experience is displayed in Table 2. Only 1 subject completed their initial athletic training education through an entry level master's program, while all others completed their initial athletic training education through an undergraduate program. All subjects attended CAATE accredited athletic training education programs. Information about the subjects' initial athletic training education is presented in Table 3. Seven subjects reported having completed an advanced degree in athletic training. Additional information about advanced education is presented in Table 4. All subjects reported having been taught how to remove American football helmets, while 3 were also taught to remove men's lacrosse helmets, and 6 were taught to remove ice hockey helmets during their initial athletic training education.

Table 1 – Descriptive Statistics

Variable	Mean and Standard Deviation
Age (years)	26.33 ± 3.086
Experience as an ATC (years)	4.56 ± 4.115
Experience working American Football (years)	3.00 ± 4.082
Experience working Men's Lacrosse (years)	0.38 ± 0.619
Experience working Ice Hockey (years)	0.50 ± 1.265
Experience working Field Hockey (years)	0.56 ± 1.94
Days learning helmet removal during initial education	3.89 ± 2.301

Table 2 –Frequencies

Variable	Frequency (n)	Percent
Gender		
Man	10	62.5
Woman	6	37.5
Current Practice Setting		
Collegiate	16	100
Initial Athletic Training Education		
Undergraduate	15	93.75
Entry Level Masters	1	6.25
Advanced Athletic Training Degree		
No advanced degree	8	50.0
Post-professional master's degree	6	37.5
Athletic training fellowship		
Graduate assistantship	1	6.25
Athletic training residency program	1	6.25

Experience treating cervical spine injury		
Yes	9	56.25
No	7	43.75
Experience removing equipment from a spine injured athlete		
Yes	5	31.25
No	11	68.75
Frequency of helmet removal practice		
Not currently practiced	6	37.5
Annually	2	12.5
Twice a year	8	50.0
Taught to remove helmets differently than during data collection today		
Yes	7	43.75
No	9	56.25

Aim 1: Cervical Spine Motion

Based on the descriptive statistics, the American football helmet had the longest time to removal, with participants taking an average of about 1 second longer to remove this type of helmet when compared to the other three helmet types. In the sagittal plane, the American football helmet had the lowest total and maximum motion of all helmets. In the transverse plane, men's lacrosse and field hockey had the lowest total cervical spine motion, but American football had the lowest maximum cervical spine motion. In the frontal plane, ice hockey had the lowest total cervical spine motion, and the field hockey helmet had the lowest maximum cervical spine motion. All means are represented graphically for total cervical spine motion in Figure 3 and for maximum cervical spine motion in Figure 4. Despite these trends, there was no significant difference found between any of the helmet types and the total or maximum motion in each plane. There was also no significant difference found between any of the helmet types and the mean time for helmet removal. Thus, the null hypothesis cannot be rejected and there is no difference between the amount of cervical spine motion and helmet type. Means and standard deviations for each helmet type and plane of motion can be found in Table 3. F ratios and p values were found by calculating repeated measures ANOVAs between helmet type (4 levels) and the total or maximum motion in each plane. Table 4 shows means and standard deviations for each type of helmet and their total motion in each plane of motion for each trial. This data shows that the time for helmet removal decreased from the first trial to the third trial for all helmet types except for men's lacrosse, which showed little change. Every helmet except for American football had a decrease in total sagittal plane motion from Trial 1 to Trial 3. Similarly, every helmet had a decrease in total motion in the transverse plane as the ATCs completed successive trials, and in the frontal plane every helmet except for men's lacrosse and men's ice hockey had a decrease in motion from the first trial to the third trial.

Table 3 – Helmet Descriptives and Statistics

Variable	American Football	MLAX[a]	Ice Hockey	Field Hockey	F Ratio	P
Time (sec)	8.55±2.82	7.73±2.58	7.80±2.97	7.71±3.27	2.196	0.102
			Total C-spine Motion			
Sagittal	2.16±1.04	2.52±2.05	3.00±2.89	2.90±2.43	1.856	0.151
Transverse	1.93±1.08	1.90±0.97	1.99±0.94	1.90±0.91	0.101	0.959
Frontal	2.97±1.34	2.46±1.14	2.30±1.16	2.95±3.67	0.551	0.650
			Maximum C-spine Motion			
Sagittal	5.75±1.95	5.75±1.80	6.77±2.15	8.26±6.70	1.970	0.132
Transverse	5.51±2.30	6.21±3.28	6.41±3.34	6.21±3.48	0.842	0.478
Frontal	6.98±3.13	6.91±3.89	6.68±4.09	6.44±4.25[b]	0.151	0.928

[a]MLAX stands for Men's Lacrosse
[b]Due to outliers in the preliminary data, the n for the maximum c-spine motion in the frontal plane only included data from 15 subjects

Figure 3 – Total Cervical Spine Motion in Each Plane

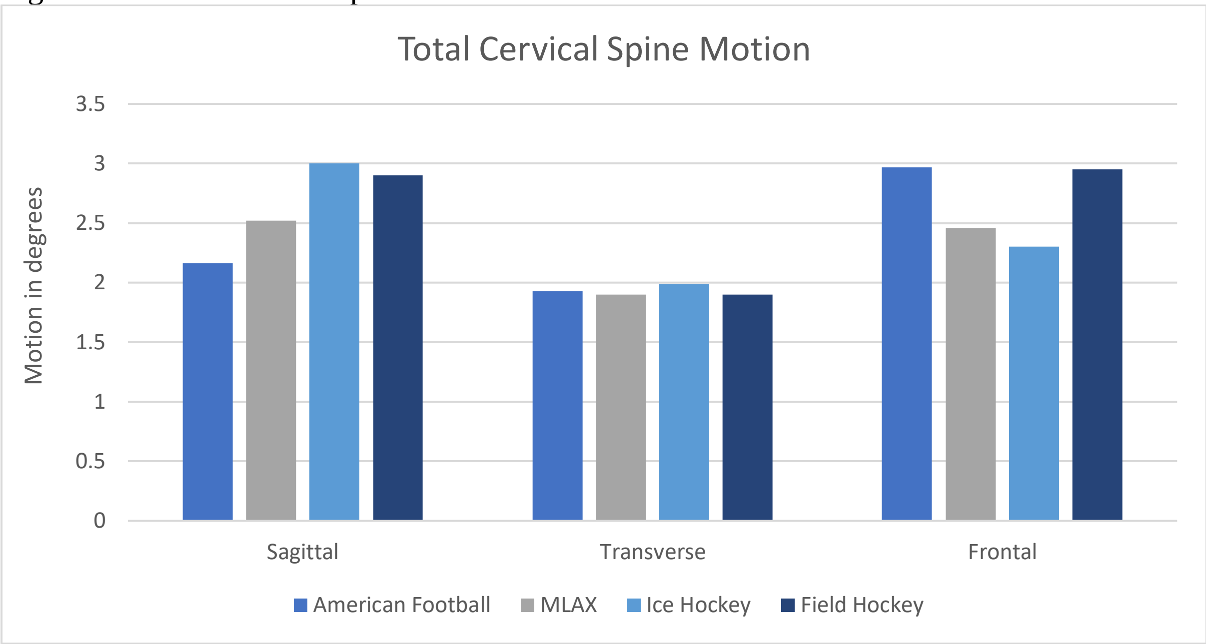


Figure 4 – Maximum Cervical Spine Motion in Each Plane

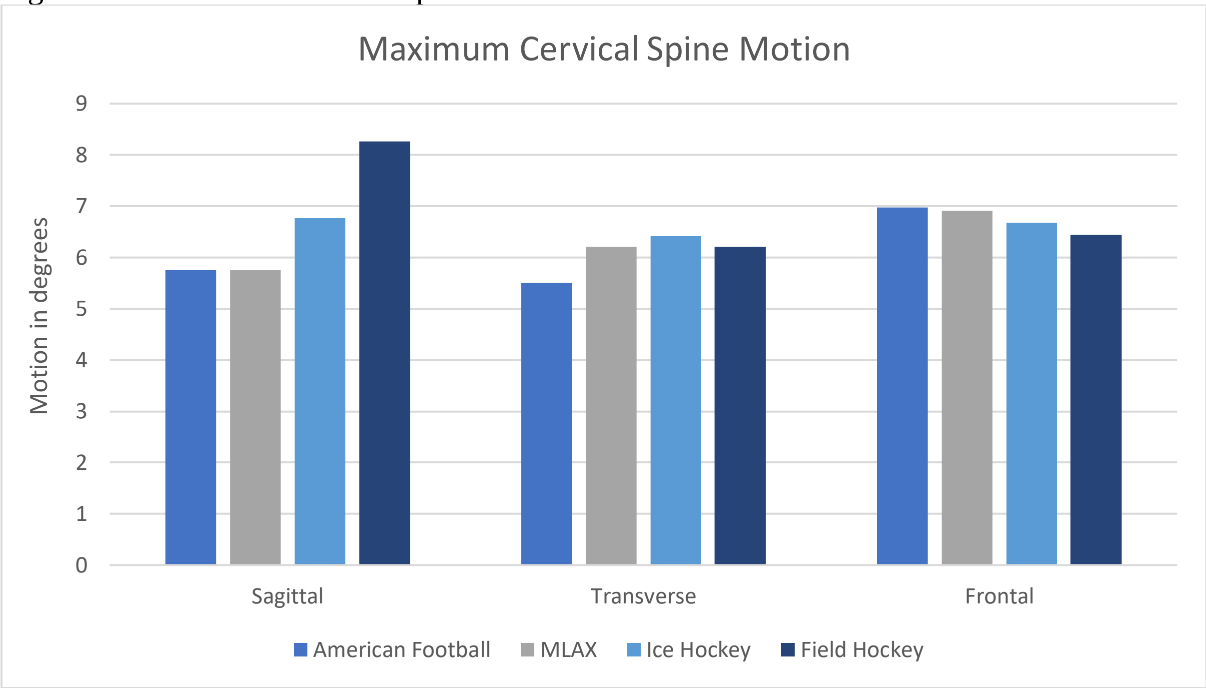


Table 4 – Descriptive Statistics for Helmet Motion by Trial

Trial Number	American Football	MLAX	Ice Hockey	Field Hockey
		Time		
Trial 1	10.19±3.87	7.34±3.40	14.55±3.07[c]	11.58±4.03[c]
Trial 2	7.69±2.51	7.77±3.75	14.29±3.94	11.38±4.81
Trial 3	7.75±3.21	7.59±3.75[a]	13.50±3.89[b]	10.78±3.96
		Total Sagittal		
Trial 1	2.09±1.05	3.17±4.36[a]	3.43±2.28[c]	5.64±8.43[d]
Trial 2	2.01±1.37	3.49±3.27	2.23±1.22	3.10±3.22
Trial 3	2.38±1.73	2.13±0.97[a]	2.20±2.37[b]	2.86±1.34
		Total Transverse		
Trial 1	2.03±1.13	1.94±1.31[a]	2.81±2.27[c]	5.40±7.65[c]
Trial 2	1.76±1.22	1.98±1.25	1.81±1.22	2.51±1.78
Trial 3	2.01±1.32	1.78±0.88[a]	1.83±1.50[b]	3.04±2.21
		Total Frontal		
Trial 1	2.91±2.70[a]	1.53±0.96[b]	3.65±2.72[e]	4.18±4.35[d]
Trial 2	3.30±1.82[a]	2.48±1.68[b]	3.17±1.77	2.41±1.35[b]
Trial 3	2.77±1.75	2.16±1.47[a]	4.37±6.85[b]	2.38±1.71[a]

* Data presented are means and standard deviations
[a]Due to outliers or a trigger issue, the indicated trials only included data from 15 subjects
[b]Due to outliers or a trigger issue, the indicated trials only included data from 14 subjects
[c]Due to outliers or a trigger issue, the indicated trials only included data from 13 subjects
[d]Due to outliers or a trigger issue, the indicated trials only included data from 12 subjects
[e]Due to outliers or a trigger issue, the indicated trials only included data from 11 subjects

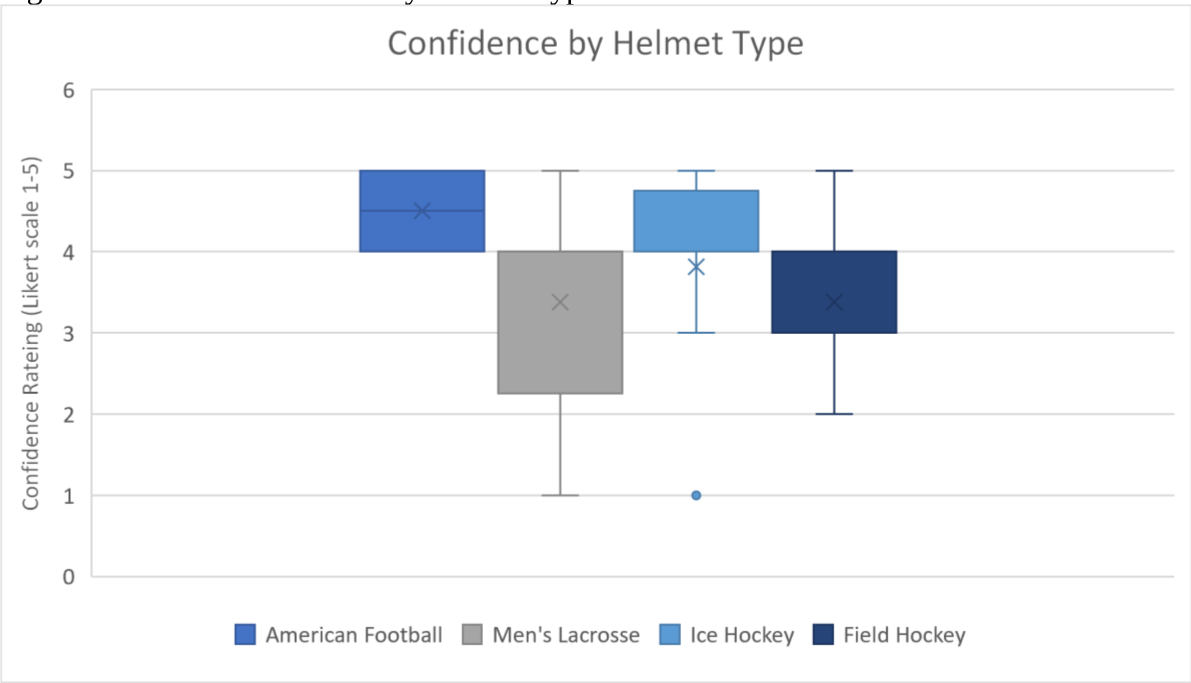
Aim 2: Athletic Trainer Confidence

The ATCs ranked their confidence on a 5- point Likert scale, with 5 being “extremely confident” and 1 being “not confident.” Table 4 shows means and standard deviations. The means indicate that men's lacrosse and field hockey had the lowest mean confidence rating and that American football had the highest confidence rating. There was a significant difference between athletic trainer confidence and helmet type ($F_{3,45} = 8.063$, $P<0.001$). Pairwise comparisons showed a significant difference between ATC confidence when removing American football helmets when comparted to men's lacrosse helmets ($P=0.008$). There was also a significant difference between ATC confidence when removing American football helmets when comparted to field hockey helmets ($P<0.001$). There was no significant difference in confidene of removing helmets between American football and ice hockey helmets ($P=4.11$), nor between any of the other helmet types (Figure 5). The American football helmet had the lowest variability of answers, as all subjects answered "confident" or "extremely confident" when they rated their removal of the American football helmet whereas the other helmet types had more variability in their confidence ratings (Figure 5). After removing all helmet types, the subjects were asked to rank the helmets from order of most confident (1) to least confident (4). Figure 6 shows the average numerical ranking for each helmet. The field hockey helmet had the average highest (least confident) and American football had the average lowest (most confident) rating.

Table 5 – Confidence Means

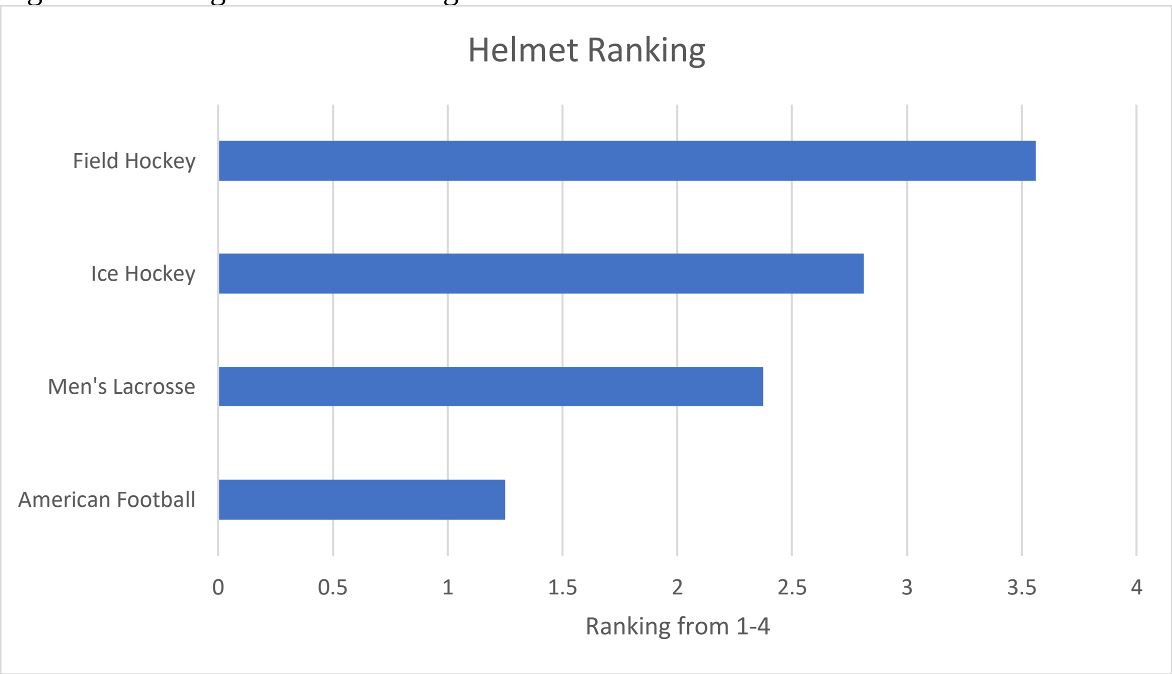
Variable	Mean and Standard Deviation
American Football	4.50±0.516
Men's Lacrosse	3.37±1.088
Ice Hockey	3.81±1.223
Field Hockey	3.38±0.957

Figure 5 – Confidence Means by Helmet Type



*At the conclusion of all three trials of a given helmet type, the subjects ranked their confidence on a five-point Likert scale. Their responses were standardized to numbers and graphed for each type of helmet.

Figure 6– Average Helmet Ranking



*After completing all trials, the subjects were asked to rank the helmets in order from 1-4 with 1 being most confident and 4 being least confident. The ratings for each helmet were averaged and graphed above.

Results Summary

Overall, the results show that there is not a significant difference between the total motion or maximum cervical spine motion between helmet types, however the American football had the lowest total cervical spine motion in the sagittal plane and the lowest maximum cervical spine motion in the sagittal and transverse planes. The American football helmet also had the highest average time for removal compared to the other three helmet types. Although there was no significant difference for total or maximum cervical spine motion, there was a significant difference in ATC perceived confidence during helmet removal and the different helmet types. Pairwise comparisons showed significant differences between confidence removing the American football helmet and the men's lacrosse and field hockey helmets, but did not find any significant differences between confidence to remove American football helmets and ice hockey helmets. The means and standard deviations showed that American football had the highest rated confidence score on the Likert scale and was also ranked as the helmet that the subjects felt most confident removing after they had completed the data collection.

CHAPTER 5
DISCUSSION

The primary purpose of this study was to evaluate cervical spine motion during helmet removal for American football, men's lacrosse, ice hockey, and field hockey helmets. The secondary purpose of this study was to evaluate ATC confidence while removing different helmet types. The hypothesis for the primary purpose was that the men's lacrosse, ice hockey, and field hockey helmets would have more motion than the American football helmets. The hypothesis for the secondary purpose was that American football athletic trainers would feel less confident when they removed men's lacrosse, ice hockey, and field hockey helmets compared to the American football helmets. Study results found no difference between maximum and normative cervical spine motion. There was a significant difference between athletic trainer confidence when removing the football helmet versus the men's lacrosse and field hockey helmets. There was no significant difference between confidence removing the football helmet versus the ice hockey helmet.

Aim 1: Cervical Spine Motion

This study found that the American football helmet had the longest time to removal compared to the other helmet types. This could be due to the American football helmet having a tighter fit than the other three helmet types, which could contribute to a longer time for removal. In the sagittal plane, the American football helmet had the lowest total and maximum motion. In the transverse plane, men's lacrosse and field hockey had the lowest total cervical spine motion, but American football had the lowest maximum cervical spine motion. In the frontal plane, ice hockey had the lowest total cervical spine motion and field hockey had the lowest maximum cervical spine motion. Overall, there does not appear to be a specific pattern for which helmets have consistently higher motion occurring in all planes of motion compared to other helmet types. This study did not find any significant difference between total motion or maximum cervical spine motion. To our knowledge, there exist no previous studies that compare cervical spine motion of different helmet types during helmet removal. Studies have previously assessed cervical spine motion during American football helmet removal,[33,34] as well as cervical alignment during removal of men's lacrosse and ice hockey helmets.[11] Such previous literature has found that men's lacrosse helmets have a looser fit than American football helmets and do not adequately stabilize the head in the helmet for athletes secured to a spineboard.[9] As such, those findings led to recommendations for removal of men's lacrosse helmets since the head will not be stabilized during transport to the hospital, therefore potentially allowing for excessive cervical spine motion during transportation.

Although the overall consensus of previous literature is split, with some recommending the removal of helmets during the pre-hospital care of athletes with spine injuries and others recommending that helmets stay in place, findings in this study showed that there is little cervical spine motion in all planes of motion during helmet removal for men's lacrosse, ice hockey, and field hockey helmets. Such findings support the thought that it is safe for athletic trainers to remove different helmet types during pre-hospital care of spine injured athletes. That said, there is no established value of permissible cervical spine motion before catastrophic injury occurs and it is difficult to draw conclusions based on cervical spine motion. Therefore, the were compared by which helmet had the least amount of head to thorax motion during emergency helmet removal.

It is important to note that many athletic trainers did not have any previous experience working with athletes wearing men's lacrosse, ice hockey, or field hockey equipment, yet they were still able to remove those helmets with no more motion compared to the American football helmet that they were more familiar with. Additionally, many athletic trainers were not taught to remove men's lacrosse or ice hockey helmets during their initial athletic training experience, and none of the subjects were taught to remove field hockey helmets. Despite this, subjects were able to translate their prior knowledge of American football helmets to adequately remove different helmet types. This shows the versatility and critical thinking skills of certified athletic trainers in their ability to remove helmets that they are not familiar with. Further, this skill is especially important for highschool athletic trainer working with multiple equipment-intensive sports, thus the versatility of athletic trainers improves sport safety. Additionally, it was observed during the data collection period that the subjects became more comfortable removing helmet types that they were previously unfamiliar with as they did more trials with the same helmet. This was apparent by the time for helmet removal showing a decreasing trend for every helmet type except for men's lacrosse, but more interestingly, the total motion decreased from the first trial to the third trial in for men's lacrosse, ice hockey, and field hockey in the sagittal plane. The average total motion also showed a decreasing trend for every helmet in the transverse plane as well as American football and field hockey in the transverse plane. This shows that athletic trainers can adapt to unfamiliar environments and still execute tasks well the more they successfully complete a task. It also shows that athletic trainers can modify their behavior. If their first trial did not feel adequate, they were able to make adjustments in their hand placement or removal tactic to make subsequent trials more effective. These findings also show the value of practice for ATCs since both the average time to remove each helmet, and the average total cervical spine motion trended to improve from trial one to trial three. Further research will be necessary to assess cervical spine motion between trials to assess if athletic trainers are able to remove different helmet types with less cervical spine motion as they continue to remove a given helmet type. Further research utilizing marker-less systems could allow for additional information regarding cervical spine motion as athletic trainers remove the facemask and helmet and could account for differences in individual helmet removal preferences

Aim 2: Athletic Trainer Confidence

Men's lacrosse and field hockey had the lowest average confidence rating and American football had the highest confidence rating on a Likert scale. Additionally, when the subjects were asked to rank the helmets in order from most confident (1) and least confident (4) the American football helmets was ranked lower on average and the field hockey helmet was ranked higher on average. This study found that field hockey helmets were ranked lowest, with ATCs being the least confident in removing them, while the American football helmet was was ranked the highest, with ATs being the most confident in removing this type of helmet. This study found a significant difference between removal of various helmet types and ATC confidence, such that there was a significant difference between ATC confidence in removing an American football helmet when compared removing a men's lacrosse or field hockey helmet. The means show that ATCs were more confident to remove the American football helmet compared to the men's lacrosse and field hockey helmets. There was no significant difference between confidence to remove the American football helmet and the confidence to remove the ice hockey helmet.

While understanding the reasoning behind such differecnes was outside the scope of this study, it is plausible that these differences in confidence may be attributed to differences in previous work experience. Five subjects reported experience working with men's lacrosse, 4 subjects reported working with ice hockey, and 5 subjects reported working with field hockey. Previous experience working with each sport may increase their familiarity with a given helmet type, causing subjects with such previous experience to feel more confident than subjects that did not have previous experience with a given helmet type. This study did not exclude subjects who had past experience working with different sports, which could have impacted the confidence ratings. To our knowledge there are no previous studies that assess athletic trainer confidence while removing different helmet types. However, previous studies have assessed confidence of athletic trainers and other healthcare providers to complete various tasks such as recognize and treat heat illness or recognize and treat concussions.[28,29]

Previous experience treating cervical spine injuries may also lead to subjects reporting feeling more confident overall compared to subjects who have not had any experience treating cervical spine injuries. Overall, 9 subjects reported having previous experience treating a cervical spine injury during their practice, and only 5 reported removing a helmet from athletes with cervical spine injuries. There are several contributing factors that could have influenced these differences in confidence, and more research will be necessary to find ways to increase athletic trainer confidence during their initial athletic training education. This research would be useful during initial athletic training education for all facets of practical athletic training education such as evaluation skills and other emergency response. As athletic training education programs become more adept at increasing athletic trainer confidence, future athletic trainers would have better outcomes and be better equipped to treat different athletic-related injuries.

Limitations

Data Collection

There are several limitations related to data collection. One limitation was that due to low equipment availability, the subjects were instructed to remove each helmet without removing facemasks or other padding. Although almost half of the subjects reported being taught to remove a helmet differently than they were instructed to do so during the data collection period, this study necessitated removing a helmet differently than the subjects' may have been taught during their initial athletic training education. This would pose a challenge for subjects that needed to remove a helmet differently than they would normally as part of their job. The seven athletic trainers who learned to remove helmets differently during their education were most commonly instructed to remove the facemask and side padding prior to removing the helmet itself. We sought to mitigate some of this by allowing three trials of each helmet removal to provide subjects with an opportunity to gain comfort in removing each helmet type regardless of their prior experiences or teaching.

Additionally, the model began with their shoulder pads already removed which is not representative of actual clinical settings. Athletes participating in each of these sports would also be wearing shoulder pads that may need to be removed in addition to the helmet, which may alter athletic trainer confidence since they are removing equipment differently than they may have been taught, and could have contributed to excess motion. Having each athletic trainer complete three trials for each helmet type accounted for the learning effect as athletic trainers continued to remove helmets. The learning effect was also accounted for by randomizing the order of helmet removal.

Another limitation was that the model was a female wearing primarily men's sports helmets, which could have contributed to decreased subject perceived confidence while removing each helmet since each subject would be more familiar with removing a helmet from male athletes. This limitation was mitigated by ensuring that each helmet was properly fit to the model's head per the manufacturer's standards. Additionally, the model's hair was dry during helmet removal, which makes it more difficult to draw conclusions that would be applicable to athletic trainers since most patients would have their hair wet from sweat during helmet removal. Future studies should work to utilize multiple models that are most like the athletes participating in helmeted sport, as well as make efforts to recreate an athletic environment.

Statistical Analysis

A power analysis completed using pilot data for this study found that a sample size of at least 15 was needed to have an alpha of 0.80 and mitigate Type 2 error. This study included 16 subjects, which satisfies the need for an appropriately powered study, but is still a smaller sample size and is difficult to represent the entire population of American football athletic trainers. After the initial data collection, there were errors where the trigger, which indicated the start and end of a trial, were missing. Any subject that had a missing trigger during one of their trials for a given helmet type was not included and the data from the other two trials were used to calculate the total and maximum cervical spine motion. For subjects that had missing triggers in more than one of their trials for a given helmet type were asked to come back to recollect their data for that helmet type. This could alter the data because subjects who needed to recollect could have had less motion than those who did not recollect their data due to the learning effect. Therefore those trials may have been improved from their initial data collection period. This was mitigated by completing three trials for each helmet type to allow for flexibility and protection of data if trigger issues occurred.

Clinical Implications

The results of this study show that American football took the longest to remove compared to the other three helmet types. Additionally, there are few patterns when assessing the motion in each plane. In the sagittal plane, the American football helmet had the lowest total and maximum motion. In the transverse plane, men's lacrosse and field hockey had the lowest total cervical spine motion, but American football had the lowest maximum cervical spine motion. In the frontal plane, ice hockey had the lowest total cervical spine motion and field hockey had the lowest maximum cervical spine motion. The results of this study show no significant difference in normative or maximum cervical spine motion between the different helmet types. There was also no significant difference found between the different helmet types and the time it took for each helmet to be removed. However, there was a significant difference between ATC confidence for American football helmets and men's lacrosse and field hockey helmets. Thus, while athletic trainers did not feel comfortable that they were completing the task well with helmets that were unfamiliar to them, their cervical spine motion was comparable to helmets that they had previous experience with. All subjects reported being taught to remove helmets during their initial athletic training education, but not all subjects were taught to remove different types of helmets and no subjects were taught to remove field hockey helmets. Additional research needs to be completed to assess which teaching techniques are best for increasing ATC confidence. The results of this study should increase athletic trainer confidence to remove unfamiliar helmets since the subjects in this study did not have any significant differences in motion between helmets despite feeling less confident. Additionally, it would be useful for initial athletic training education programs to teach a variety of different helmet types to increase confidence for athletic trainers entering equipment intensive sports other than American football.

Aside from advancing educational techniques, this information is useful for practicing athletic trainers because current recommendations by the NATA only recommend the removal of the facemask of a helmet without removing the rest of the helmet. If the helmet must be removed, the current recommendations recommend complete removal of the helmet and shoulder pads. The results of this study support helmet removal during the pre-hospital care of spine injured athletes since the time for removal was less than 10 seconds and the cervical spine motion was small throughout the removal process. It is thought that hypoxic injury to the spinal cord can occur in four to five minutes, so 10 seconds is very brief and should be adequate to avoid hypoxic injury.[23]

Conclusions

Overall, the findings showed no significant difference between total or maximal cervical spine motion between the different helmet types. There was also no significant difference in the time it took for helmet removal between the different helmet types. Despite there being no significant differences in cervical spine motion, there was a significant difference in ATC confidence between the different American football and men's lacrosse and field hockey helmets. Confidence is multi-faceted and it is likely that previous experience working with different sports, previous experience treating cervical spine injuries, and previous experience during their initial athletic training education are all factors that could increase ATC confidence while removing helmets and could explain why some subjects who did not have these experiences were less confident. Further research is necessary to assess optimal teaching styles that best increase confidence.

APPENDIX A: SCENARIO

For the purposes of data collection today you are an athletic trainer covering the following sporting events: American football, men's lacrosse, ice hockey, and field hockey. For each of these sports an athlete sustains an axial load to the head. After completing your evaluation, you have decided they have a potential cervical spine injury and have chosen to remove their helmet. I will be holding C-spine from the front for each trial. You will be asked to remove each helmet three times. Due to limited equipment availability, we ask that you remove the helmets without unscrewing, or cutting anything. We also ask that you do not remove any side padding. Do you have any questions before we begin?

APPENDIX B: CONSENT FORM

University of North Carolina at Chapel Hill
Consent to Participate in a Research Study
Adult Participants
Consent Form Version Date: 11-7-2021
IRB Study # 21-2792
Title of Study: Cervical Spine Motion and Athletic Trainer Confidence During Helmet Removal
Principal Investigator: Rebecca Hersch
Principal Investigator Department: Exercise and Sport Science
Principal Investigator Phone number: (919) 962-2067
Principal Investigator Email Address: herschrf@email.unc.edu
Faculty Advisor: Meredith Petschauer
Faculty Advisor Contact Information: (919) 962-1110

What are some general things you should know about research studies?
You are being asked to take part in a research study. To join the study is voluntary. You may refuse to join, or you may withdraw your consent to be in the study, for any reason, without penalty.

Research studies are designed to obtain new knowledge. This new information may help people in the future. You may not receive any direct benefit from being in the research study. There also may be risks to being in research studies. Deciding not to be in the study or leaving the study before it is done will not affect your relationship with the researcher, your health care provider, or the University of North Carolina at Chapel Hill. If you are a patient with an illness, you do not have to be in the research study in order to receive health care.

Details about this study are discussed below. It is important that you understand this information so that you can make an informed choice about being in this research study.

You will be given a copy of this consent form. You should ask the researchers named above, or staff members who may assist them, any questions you have about this study at any time.

Catastrophic cervical spine injuries can result in paralysis and even death if mismanaged. Most of the existing research available to help guide the athletic trainer's practice is primarily based on American Football athletes, however these injuries occur in other equipment intensive sports such as men's lacrosse, ice hockey, and field hockey. These sports have different styles of helmets compared to American football and therefore additional research is necessary to make appropriate recommendations for athletic trainers practicing with these sports. The purpose of this study is to evaluate the cervical spine motion during helmet removal across various helmet types. We also want to assess the confidence of certified American football athletic trainers to remove different helmet types in potential spine injured athlete.

Why are you being asked to be in this study?
You are being asked to be in the study because you are a certified and licensed athletic trainer who is currently working or has worked American football within the last five years.

What if you are a UNC student?
You may choose not to be in the study or to stop being in the study before it is over at any time. This will not affect your class standing or grades at UNC-Chapel Hill. You will not be offered or receive any special consideration if you take part in this research.

What if you are a UNC employee?
Taking part in this research is not a part of your University duties, and refusing will not affect your job. You will not be offered or receive any special job-related consideration if you take part in this research.

Are there any reasons you should not be in this study?
You should not be in this study if you:
1) Are not a certified and licensed athletic trainer
2) You have not worked American football within the last 5 years of your career
3) Are unable to report to the University of North Carolina at Chapel Hill for a 1 hour testing session
4) You have an upper extremity injuries that would limit or prevent you for adequately removing any type of helmet from an athlete

How many people will take part in this study?
There will be approximately 30 people in this research study.

How long will your part in this study last?
You have already completed a brief scheduling survey. Now that you are eligible, you will be asked to attend one testing session at the University of North Carolina at Chapel Hill that will last approximately 1 hour. There are no follow-up meetings that are required.

What will happen if you take part in the study?
You will be asked to report to the Neuromuscular Research Laboratory (Fetzer Hall) on the UNC-CH campus. When you arrive to the laboratory, you will be read a brief scenario describing that one of your athletes has experienced a possible cervical spine injury. The scenario will detail that you have already completed your evaluation of the athlete and have decided to remove the helmet. A model will by lying supine with their head and neck in a neutral position wearing the first helmet to be removed (helmet order will be randomized and pre-determined by a computer). You will remove each helmet three times to the best of your knowledge. After completing each helmet type, you will complete a brief survey that will assess how confident you felt while removing that type of helmet while the model is prepared with the next helmet. You will remove four helmets total.

Once you’ve removed all four helmets, you will complete a final survey that will ask about your demographic information, athletic training education, and their experience and comfort removing various types of helmets

The research team would also like to keep your contact information, without links to your study ID, in case you are eligible for future investigations. You do not need to let us keep your contact information to participate in this study.

Can we keep your contact information (Circle one)? YES NO

The research team would also like to keep your data, without links to your name, to perform additional analyses in the future. You do not need to let us keep your data for future secondary analysis to participate in this study.

Can we keep your data for additional analyses (Circle one)? YES NO

What are the possible benefits from being in this study?

Research is designed to benefit society by gaining new knowledge. You will not benefit personally from being in this research study.

What are the possible risks or discomforts involved from being in this study?

The risks associated with participation in this research study are minimal and highly unlikely. There may be uncommon or previously unknown risks from participating in this study. You should report any problems to the researcher.

What if we learn about new findings or information during the study?

You will be given any new information gained during the course of the study that might affect your willingness to continue your participation.

How will information about you be protected?

Any information obtained in connection with this research study that can be linked to you will remain confidential. You will be identified only by a subject identification number. A code list that associates your name and information with a subject identification number will be kept under key-card access on a password-protected computer in the Neuromuscular Assessment Laboratory, and will be destroyed when the study is completed.

Participants will not be identified in any report or publication about this study. Although every effort will be made to keep research records private, there may be times when federal or state law requires the disclosure of such records, including personal information. This is very unlikely, but if disclosure is ever required, UNC-Chapel Hill will take steps allowable by law to protect the privacy of personal information. In some cases, your information in this research study could be reviewed by representatives of the University, research sponsors, or government agencies (for example, the FDA) for purposes such as quality control or safety.

What will happen if you are injured by this research?

All research involves a chance that something bad might happen to you. This may include the risk of personal injury. In spite of all safety measures, you might develop a reaction or injury from being in this study. If such problems occur, the researchers will help you get medical care, but any costs for the medical care will be billed to you and/or your insurance company. The University of North Carolina at Chapel Hill has not set aside funds to pay you for any such reactions or injuries, or for the related medical care. You do not give up any of your legal rights by signing this form.

What if you want to stop before your part in the study is complete?
You can withdraw from this study at any time, without penalty. The investigators also have the right to stop your participation at any time. This could be because you have had an unexpected reaction, or have failed to follow instructions, or because the entire study has been stopped.

Will you receive anything for being in this study?
You will not receive anything for being in this study.

Will it cost you anything to be in this study?
It will not cost you anything to be in this study.

What if you have questions about this study?
You have the right to ask, and have answered, any questions you may have about this research. If you have questions about the study, complaints, concerns, or if a research-related injury occurs, you should contact the researchers listed on the first page of this form.

What if you have questions about your rights as a research participant?
All research on human volunteers is reviewed by a committee that works to protect your rights and welfare. If you have questions or concerns about your rights as a research subject, or if you would like to obtain information or offer input, you may contact the Institutional Review Board at 919-966-3113 or by email to IRB_subjects@unc.edu.

Participant's Agreement:
I have read the information provided above. I have asked all the questions I have at this time. I voluntarily agree to participate in this research study.

____ ________________
Signature of Research Participant Date

____
Printed Name of Research Participant

____ ________________
Signature of Research Team Member Obtaining Consent Date

____
Printed Name of Research Team Member Obtaining Consent

APPENDIX C: SURVEY INSTRUMENT

Final Helmet Survey

Start of Block: Demographics

Q1 Please enter the ID number provided to you here

____

Q2 How old are you? Please answer in years

▼ 21 (4) ... 85+ (103)

Q3 What gender do you identify with?

○ Man (1)

○ Woman (2)

○ Non-binary / third gender (3)

○ Prefer not to say (4)

Q4 In what year did you pass your BOC?

▼ 1970 (4) ... 2021 (56)

Q5 How long have you been a practicing athletic trainer in years?

▼ 1 (4) ... 31+ (54)

Q6 In which setting do you currently practice as an athletic trainer?

- ○ Secondary School (i.e. public high school or private high school (1)
- ○ Collegiate (i.e. NCAA, NAIA, JuCo) (2)
- ○ Other (Please specify) (3) ____

Q7 Have you worked with any of the following sports during your career? (select all that apply)

- ▢ Men's Lacrosse (1)
- ▢ Ice Hockey (2)
- ▢ American Football (3)
- ▢ Field Hockey (4)

Display This Question:

If Have you worked with any of the following sports during your career? (select all that apply) = Men's Lacrosse

Q8 How many years have you worked with men's lacrosse?

▼ 1 (4) ... 25+ (29)

Display This Question:

If Have you worked with any of the following sports during your career? (select all that apply) = Ice Hockey

Q9 How many years have you worked with men's ice hockey?

▼ 1 (4) ... 25+ (28)

Display This Question:

If Have you worked with any of the following sports during your career? (select all that apply) = American Football

Q10 How many years have you worked with American football?

▼ 1 (4) ... 25+ (30)

Display This Question:

If Have you worked with any of the following sports during your career? (select all that apply) = Field Hockey

Q11 How many years have you worked with field hockey

▼ 1 (1) ... 25+ (27)

End of Block: Demographics

Start of Block: Education

Q12 Through which type of program did you complete your initial athletic training education? (i.e. your education program prior to sitting for the BOC exam)

- Undergraduate (1)
- Entry Level Master's (2)
- Internship Route (prior to 2004) (3)

Q13 In what year did you complete your initial athletic training education?

▼ 1970 (4) ... 2021 (57)

Q14 In what area of study did you complete your initial athletic training degree?

○ Athletic Training (4)

○ Health Science (5)

○ Exercise Physiology (6)

○ Kinesiology (7)

○ Other (please specify) (8) ____

Q15 Was your initial athletic training education program CAATE accredited?

○ Yes (1)

○ No (2)

○ Unsure (3)

Q16 Have you completed an advanced degree in athletic training? (Select all that apply)

- ☐ No advanced degree in athletic training or a related field (1)
- ☐ Post-Professional Master's Degree (2)
- ☐ Athletic Training Graduate Assistantship (3)
- ☐ Doctorate in Athletic Training (4)
- ☐ Athletic Training Residency Program (5)
- ☐ Athletic Training Fellowship (6)
- ☐ Advanced degree in a related field (i.e. exercise science, kinesiology, sport administration etc.) (7)
- ☐ Other (please specify) (8) ____

Skip To: End of Block If Have you completed an advanced degree in athletic training? (Select all that apply) = No advanced degree in athletic training or a related field

Q17 When did you complete your advanced degree in athletic training?

▼ 1970 (4) ... 2020 (54)

End of Block: Education

Start of Block: Helmet Removal

Q18 Were you taught to remove helmets during your graduate or undergraduate education?

○ Yes (1)

○ No (2)

Skip To: End of Block If Were you taught to remove helmets during your graduate or undergraduate education? = No

Q19 Which helmets were you taught to remove during your undergraduate education? Select all that apply

- ☐ Men's Lacrosse (1)
- ☐ Ice Hockey (2)
- ☐ American Football (3)
- ☐ Other (4) ____

Q20 How much time (in days) did your undergraduate education focus on helmet removal?

▼ 1 (4) ... 15+ (18)

Q21 Please specify how you were taught to remove a helmet during your undergraduate or graduate education?

____

End of Block: Helmet Removal

Start of Block: C-Spine Injury

Q22 Have you ever treated an athlete with a potential cervical spine injury?

○ Yes (1)

○ No (2)

Q23 Have you ever removed a helmet from an athlete with a potential cervical spine injury?

○ Yes (1)

○ No (2)

Display This Question:

If Have you ever treated an athlete with a potential cervical spine injury? = Yes

Q24 How many times have you treated an athlete with a potential cervical spine injury?

▼ 1 (5) ... 10+ (16)

Display This Question:

If Have you ever removed a helmet from an athlete with a potential cervical spine injury? = Yes

Q25 How many times have you removed a helmet from an athlete with a potential cervical spine injury?

▼ 1 (5) ... 10+ (15)

Q26 In your current position how often do you practice helmet removal?

- ◯ I do not practice helmet removal (1)
- ◯ Annually (once a year) (2)
- ◯ Twice a year (3)
- ◯ Every other year (4)
- ◯ Every 5 years (5)
- ◯ Other (Please explain) (6) ____

End of Block: C-Spine Injury

Start of Block: Removal Confidence

Q27 A this point, please hand the iPad or computer to a member of the research team. They will periodically hand it back to you over the next few minutes.

Q28 **Research Team Member** - What will be the order of helmet removal today?

	First (1)	Second (2)	Third (3)	Fourth (4)
American Football (1)	○	○	○	○
Ice Hockey (2)	○	○	○	○
Men's Lacrosse (3)	○	○	○	○
Field Hockey (4)	○	○	○	○

Display This Question:

If Research Team Member - What will be the order of helmet removal today? = First

Carry Forward Selected Choices from "Research Team Member - What will be the order of helmet removal today? "

X→

Q29 How confident did you feel while removing the following helmet type?

	Not Confident (1)	Somewhat Confident (2)	Unsure (3)	Confident (4)	Extremely Confident (5)
American Football (x1)	○	○	○	○	○
Ice Hockey (x2)	○	○	○	○	○
Men's Lacrosse (x3)	○	○	○	○	○
Field Hockey (x4)	○	○	○	○	○

Display This Question:

If Research Team Member - What will be the order of helmet removal today? = Second

Carry Forward Selected Choices from "Research Team Member - What will be the order of helmet removal today? "

X→

Q30 How confident did you feel while removing the following helmet type?

	Not Confident (1)	Somewhat Confident (2)	Unsure (3)	Confident (4)	Extremely Confident (5)
American Football (x1)	○	○	○	○	○
Ice Hockey (x2)	○	○	○	○	○
Men's Lacrosse (x3)	○	○	○	○	○
Field Hockey (x4)	○	○	○	○	○

Display This Question:

If Research Team Member - What will be the order of helmet removal today? = Third

Carry Forward Selected Choices from "Research Team Member - What will be the order of helmet removal today? "

Q31 How confident did you feel while removing the following helmet type?

	Not Confident (1)	Somewhat Confident (2)	Unsure (3)	Confident (4)	Extremely Confident (5)
American Football (x1)	o	o	o	o	o
Ice Hockey (x2)	o	o	o	o	o
Men's Lacrosse (x3)	o	o	o	o	o
Field Hockey (x4)	o	o	o	o	o

Display This Question:

If Research Team Member - What will be the order of helmet removal today? = Fourth

Carry Forward Selected Choices from "Research Team Member - What will be the order of helmet removal today? "

X→

Q32 How confident did you feel while removing the following helmet type?

	Not Confident (1)	Somewhat Confident (2)	Unsure (3)	Confident (4)	Extremely Confident (5)
American Football (x1)	o	o	o	o	o
Ice Hockey (x2)	o	o	o	o	o
Men's Lacrosse (x3)	o	o	o	o	o
Field Hockey (x4)	o	o	o	o	o

End of Block: Removal Confidence

Start of Block: Overall and Wrap Up

Q33 Thank you for completing the helmet removal portion of the study. The last few questions will ask about your overall experience today.

Q34 Were taught to remove helmets during your education differently than the way you removed the helmets today?

- ○ Yes (1)
- ○ No (2)

Display This Question:

If Were taught to remove helmets during your education differently than the way you removed the helm... = Yes

Q35 Please specify how you were taught to remove a helmet during your undergraduate or graduate education (select all that apply).

- ☐ Instructed to remove the face-mask before the helmet (1)
- ☐ Instructed to remove the helmet padding before removing the helmet (2)
- ☐ Instructed not to remove the helmet (3)
- ☐ Other (please specify) (4) ____

Q36 How confident did you feel **overall** while removing the helmets today

- ○ Extremely Confident (1)
- ○ Confident (2)
- ○ Unsure (3)
- ○ Somewhat Confident (4)
- ○ Not Confident (5)

Q37 10. Please rank these helmets in order from most confident (1) to least confident (4)?

_______ Men's Lacrosse (1)
_______ Men's Ice Hockey (2)
_______ American Football (3)
_______ Field Hockey (4)

Q38 On a scale from 0-100 please rate how well you felt you performed today while removing the helmets (0 being poor, 100 being perfect)

	Not well at all	Slightly well	Moderately well	Very well	Extremely well
	0 10	20 30	40 50 60	70 80	90 100
Click to write Choice 1 ()					

Q39 On a scale from 0-100 please rate how confident you are in your ability to execute the skill of removing any kind of helmet during your clinical practice (0 being not confident at all, 100 being completely confident)

	0 10 20 30 40 50 60 70 80 90 100
Click to write Choice 1 ()	

End of Block: Overall and Wrap Up

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