May 2017

Concussion Prevention Strategies: A Survey of Division I and Division II Female Soccer Teams

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CONCUSSION PREVENTION STRATEGIES: A SURVEY OF DIVISION I AND DIVISION II FEMALE SOCCER TEAMS

By

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Bachelor of Science – Athletic Training
Grand Canyon University
2014

A thesis submitted in partial fulfillment
of the requirements for the

Master of Science – Kinesiology

Department of Kinesiology and Nutrition Sciences
School of Allied Health Sciences
Division of Health Sciences
The Graduate College

University of Nevada, Las Vegas
May 2017

UNLV | GRADUATE COLLEGE

Thesis Approval

The Graduate College
The University of Nevada, Las Vegas

April 19, 2017

This thesis prepared by

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entitled

Concussion Prevention Strategies: A Survey of Division I and Division II Female Soccer Teams

is approved in partial fulfillment of the requirements for the degree of

Master of Science – Kinesiology
Department of Kinesiology and Nutrition Sciences

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ABSTRACT

Concussion prevention strategies: A Survey of division I and division II female soccer teams

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The purpose of this study is to evaluate concussion prevention strategies that are being used in NCAA Division I and Division II schools, perform an investigation of cervical strengthening programs and the concussion rates associated, and determine beliefs of Certified Athletic Trainers about equipment for concussion prevention. Participants included Certified Athletic Trainer's (ATs) employed at NCAA Division I and Division II universities in the United States, and provide services to the universities' female soccer team. Data was collected via questionnaire e-mailed to participants through Qualtrics survey software. A prompt was sent out two weeks and four weeks following the initial e-mail to those individuals who had yet to respond. Data was analyzed using Qualtrics data analysis and reports. Descriptive statistics were calculated on changes in concussion rates following a cervical strengthening/stability program, concussion prevention strategies being used, and perceptions of preventative methods for concussions. Each question was analyzed individually based on the number of responses per question. Responses were received from 245 schools (41.7%), 22 of which were excluded as they did not meet inclusion criteria requirements. Thirty-eight teams (17.12%) are implementing some form of cervical strengthening or stability program for concussion prevention, 177 teams (79.73%) are not, and seven ATs (3.15%) did not know if a program was being implemented. Ten teams (55.6%) had a reduction in the number of concussions the year after implementation, ranging between one to seven fewer concussions than the year prior. Seven teams (38.9%)

suffered the same number of concussions the year prior and the year after implementing a program. One team (0.06%) had one more concussion than the year prior to implementation of a cervical strengthening program. Five ATs were not able to provide information for the year following as they had not yet completed a full Fall and Spring season since initially implementing a program. One-hundred fifty-three (69.86%) ATs believe that a cervical strengthening or stability program will aid in the prevention of concussions, while 66 (30.14%) do not believe it will prevent concussions. Thirty-six teams (16.59%) are implementing preventative equipment. One-hundred fifty-one teams (69.59%) are implementing education on proper technique to prevent concussions. Fourteen teams (0.06%) are implementing nutritional strategies for concussion prevention. Seventeen teams (0.08%) are implementing other concussion prevention strategies. Nineteen ATs (8.76%) believe that headgear prevents concussions in soccer, while 198 ATs (91.24%) believe headgear does not prevent concussions. Seventy-eight teams (35.49%) have players that wear headgear. One-hundred thirty-nine teams (64.06%) do not have any players on the team that wear headgear. Forty-five ATs (20.74%) believe that mouth guards prevent concussions in soccer, while 172 (79.26%) believe they do not prevent concussions. Results revealed a disconnect between current literature and perceptions held by ATs of concussion prevention tools. A wide range of concussion prevention strategies are being employed at the collegiate level for concussion prevention. Future research is required to determine the effects of neck strengthening on concussion rates.

ACKNOWLEDGEMENTS

I would first like to thank Dr. Kara Radzak, my committee chair, for her guidance throughout this project. This would not have been possible without the time she spent helping me culminate this concept and developing a thesis that I am extremely passionate about. She has had a ridiculously heavy load as only a second-year faculty member at the University of Nevada, Las Vegas, while also advising several other graduate students including myself. I am very grateful to have had the opportunity to work with her through my master's degree. I would also like to thank the members of my committee: Dr. Richard Tandy, Mr. Tedd Girouard, and Dr. Merrill Landers. I appreciate the time that each of them has taken out of their busy schedules to aid me in developing my thesis. The collaboration that I received during my pre-prospectus and proposal meetings was fantastic, and only elevated my excitement for this project. I cannot thank each of them enough.

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CHAPTER ONE: INTRODUCTION

In recent years, the United States has seen a dramatic increase in the number of sports-related concussions. According to the Center for Disease Control, between the years of 2001 to 2009 there was an increase in the number of Emergency Room (ER) visits related to traumatic brain injuries (TBIs) from approximately 153,000 to more than 248,000, the majority of which were individuals between the ages of 10-19.[1] There are several theories behind this rapid climb in ER visits, including a rise in the number of children participating in sports, the increased intensity of contact sports, or that awareness of the long-term severity of concussions has increased, where parents and children are attempting to recognize and report them.[2] Common long-term post-concussive symptoms include agitation, paranoia, aggressive behavior, impaired judgment, and depression, with increased risk for severe depression throughout the lifespan.[3] These serious neurobehavioral side effects can ensue following multiple or repeated concussions without appropriate diagnosis and recovery.[3] Athletic trainers (ATs) and various health care professionals have continued to make great efforts towards improving their approach to concussion management, using the most recent conservative return-to-play (RTP) protocols, diagnostic tools, and injury prevention strategies.

Before we can grasp the importance of concussion awareness and prevention, we must first understand what a concussion is. A concussion, is a mild traumatic brain injury (mTBI) induced by traumatic biomechanical forces resulting in a complex pathophysiological process affecting the brain.[4,5] Following injury to the brain, a secondary injury known as the neurometabolic cascade ensues, resulting in a transient state of excitotoxicity that eventually leads to neuronal exhaustion.[6] This phenomenon produces post-concussive symptoms such as prolonged memory loss, increased agitation, and sleep disturbances.[7] Concussions can be caused by several mechanisms of injury that can be broadly categorized into three types: coup, contrecoup, and rotational.[8] A coup injury occurs when a moving object strikes a stationary individual, such as a soccer ball being headed by a player, causing injury to the brain on the same side of impact.[8] A contrecoup injury occurs when a moving player strikes a stationary object, for example when a goalie dives and strikes their head on a goal post, causing injury to the brain on the opposite side of impact.[8] Concussions caused by a rotational mechanism are the most severe as they create shearing forces on brain tissue,[9] such as those occurring when a boxer takes a hook to the chin. Additionally, a concussion may occur from an impulsive force impacting the body that is transferred into the head, similarly to what would occur when a quarterback is sacked unexpectedly to the body causing "whiplash" that disrupts the brain in the skull.[10] Many times, this may result in a coup and contrecoup injury as impact occurs at two points on the brain.[8]

Several studies have been performed evaluating the differences in rates of concussions between genders and various sports. In a recent study performed at The Research Institute at Nationwide Children's Hospital in Columbus, Ohio, researchers compared athlete exposure and injury incidence data from 20 sports during the academic years of 2008-2010 in high school athletics.[11] They found that of the 14,635 injuries that were reported within this time and 13.2% were concussions.[11] Although the majority of these concussions occurred from participation in football, the second most common sport was women's soccer.[11] Among soccer players, girls suffered from a concussion almost twice as often as boys, and concussions represented 15.4% of the total injuries within women's soccer.[11] Additionally, more than 60% of both female and male concussions suffered during soccer practices and matches were sustained while heading the ball.[11] These findings were consistent with a literature review published in the *British Journal of Sports Medicine* which reported that female soccer players sustained a concussion 2.4 times more often than male soccer players, and a higher percentage of female concussions occurred from contact with the ball rather than with another player or surface.[12] With this information and the increasing need for intervention, US Youth Soccer issued an updated version of concussion guidelines as part of their Campaign for Player Safety in December of 2015. These new recommendations included the elimination of heading in both practices and games in all programs U11 and younger, as well as a limitation of the amount of heading performed in practice for ages 11-13.[13] US Youth Soccer also recommended that a health care professional be on site at all major tournaments, and that players who may have suffered from concussion will not be penalized a substitution for evaluation.[13]

In the sports community, attempts have been made to prevent coup mechanisms by providing additional barriers between the head and potential impact areas. The rapid increase in the use of protective headgear has been associated with evidence revealing newer helmet models in football to reduce translational and rotational accelerations, as well as peak Gs.[14] Although reduced accelerations and peak G forces are pertinent information in regard to diffuse axonal injury, there is little evidence to support the use of protective equipment that will prevent or reduce the risk for concussion injuries.[14-16] A study performed by Tierney and associates in 2008, focused on identifying differences in head accelerations between gender and soccer headgear types while heading a ball.[17] Results showed that women displayed much greater head accelerations while heading with Head Blast headgear (32% greater) and Full 90 Select headgear (44% greater) when compared with male counterparts.[17] Additionally, the control condition wearing no headgear revealed only slightly greater head accelerations while heading the ball in women versus men (10% greater).[17] These findings suggest that adding headgear might actually increase head accelerations during heading which can lead to a higher potential for suffering from a concussion and increased severity.[17] In another study performed on rugby players in Australia, researchers aimed to determine if padded headgear prevented head injury in male rugby players between the ages of 12-21 years.[18] Results showed that there were no significant differences in concussion incidence between players without headgear, with standard headgear, and with modified headgear.[18] These results indicate that the use of headgear did not reduce concussion risk. Although some research has shown reductions in peak forces during higher impacts while wearing headgear, a conclusive link has not been made with the use of headgear and the incidence of concussion.[16]

A promising area of increased research focus is that of cervical muscular factors as a predictive aspect of head impacts. Schmidt et al. reported that football players with greater cervical stiffness and less angular displacement after an applied perturbation decreased the chances of elevated magnitude head impacts.[19] Another study attempting to identify neck strength as a protective factor reducing concussions revealed that lower overall neck strength was significantly correlated with concussion occurrence in both lacrosse and basketball.[20] These findings indicate that neck strengthening exercises are a potential preventative tool and emphasizes the need for further, more definitive research.[15]

As previously stated, there is currently a lack of consensus on preventative measures for concussions. The present study will attempt to provide a thorough investigation of those concussion prevention strategies being used by collegiate female soccer teams. It will also investigate cervical strengthening programs being implemented and the associated concussion rates. Additionally, perceptions of concussion prevention strategies will be evaluated. It should be noted that findings from this study do not necessarily apply to all athletes as objective and technique vary drastically from a sport such as soccer in comparison to football. Due to the constraints of study design on population, the results of this study may be translated to the specific group of college-aged female soccer players. In addition, there is research lacking on the techniques that are being used by health care professionals to help prevent concussive injuries and the reasons why these strategies are being used in some high-level schools and not others. This study will present possible trends among those schools that are not implementing a cervical strengthening program, allowing for steps to be taken if possible to eliminate these barriers for the betterment of young athletes.

With the current information presenting high risk of concussion in soccer, an increased risk in females, and the potential of neck strengthening as a preventative intervention, there is a need to evaluate the current use of concussion prevention strategies in this at-risk population. Therefore, the purpose of this study is to evaluate concussion prevention strategies that are being taken in NCAA Division I and Division II women's soccer programs. A secondary purpose is to perform an in-depth investigation of cervical strengthening and its correlation to concussion rates. A final purpose is to determine beliefs of ATs about widely used concussion prevention strategies. To attain this goal, a survey was sent out to each Sports Medicine Department of NCAA Division I and Division II schools that have a female soccer team. This survey contains questions regarding where and to whom athletic training services are provided, the implementation of a cervical strengthening program, concussion rates, and personal beliefs on concussion prevention strategies.

This survey aims to answer three primary research questions: Does implementation of any form of neck strengthening or stability program relate with changes in concussion rates in high-level collegiate female soccer players? What concussion prevention strategies are currently being used by Division I and Division II universities? What perceptions are held by ATs of proposed concussion prevention strategies?

CHAPTER TWO: LITERATURE REVIEW

To develop a better understanding of the purpose of the proposed study, an in-depth review of literature is necessary. This literature review will discuss several influential factors including age, gender, and sports as they differ in reports of concussion. Current research of preventative strategies will also be deliberated and their effectiveness on reducing concussions. Particularly, neck strength and its relationship to concussion contributors will be analyzed to determine what we know, as well as what gaps must be filled.

Influence of Gender, Age, and Sport on Concussion Incidence

There are varying reports of gender differences in the occurrence of concussion. In a study performed by Gessel and colleagues, an evaluation was performed on 100 high schools and 180 colleges using two injury tracking databases.[21] Gessel found that among all concussions that occurred in high school and collegiate settings, females incurred a higher number when compared to males.[21] When comparing men to women per sport, findings revealed that females still received a greater number of concussions than their male counterparts in soccer (36% girls, 22% boys), basketball (21% girls, 7% boys), and softball (7% girls, 5% boys).[21] A literature review was performed by RW Dick in 2009 to determine if there were gender differences in concussion incidence and outcomes.[12] Using a PubMed search, 10 studies were included in the evaluation of incidence, nine of which indicated that concussion rates in females were higher than those in males (four of which were considered statistically significant).[12] A total of five studies were included in concussion mechanism, where males were found to have a higher absolute percentage of player contact causing concussions, while females had higher percentages of surface or ball contact resulting in a concussion.[12] Six articles were reviewed for outcomes, resulting in traumatic brain injury consequences that prove to be worse in females than in males in the majority of measured variables including number of symptoms, symptom severity, and time to recovery.[12] These findings would continue to indicate that females are at a higher risk for concussion, and that these injuries are primarily occurring from contact from something other than another player.

Furthermore, gender differences have also been noted in dynamic stabilization during head acceleration. As research continues to identify that females may be at a higher risk for concussion, research has not been able to address the more important question as to why this is true. Research performed by Tierney et al. sought to identify a possible answer to this dilemma.[22] Researchers postulated that insufficient muscular strength of dynamic stabilizers of the head may predispose athletes to concussion as they would not be able to counter external forces to reduce head acceleration.[22] As it is well known that females have less segmental mass of the neck than males, researchers hypothesized that this was the reason that females suffer from concussion more often than males.[22] Tierney and colleagues designed a three-factor study to determine whether there are gender differences in kinematic and dynamic stabilization responses when an external force is applied to the head.[22] Forty individuals were included in this study, 20 males (age 26.3 ± 4.3yrs) and 20 females (age 24.2 ± 4.1yrs).[22] Individuals were excluded if they had a history of neurological disorder, previous head or neck injury, or had been participating in a cervical strengthening program within the previous six months to data collection.[22] Head-neck segment mass was determined by multiplying body mass by the gender specific head-neck segment to total body mass percentage.[22] Head-neck segment length and neck girth were also determined.[22] Kinematic assessment was collected via PEAK Motus Motion Analysis System with markers placed on head-neck and torso segments to analyze head-neck flexion and extension peak angular acceleration and displacement.[22] EMG assessment was taken with the Noraxon System of the SCM and trapezius.[22] Isometric strength assessment was determined using a hand-held dynamometer for flexor and extensor strength[22]. Participants initially performed neck warm-ups and stretching, at which point they were fitted with headgear and seated within the external force applicator.[22] Individuals performed three maximum isometric contractions in flexion and extension.[22] They then had their eyes and ears covered to limit visual and auditory feedback while the external force applicator was attached to the headgear.[22] Examiners would then drop a 1kg mass from 15cm to apply load to the head-neck segment in either flexion or extension while participants were asked to stabilize the head to prevent movement.[22] Three trials were performed while individuals knew the force was going to occur and three while they did not know.[22] Data was analyzed using SPSS software with multiple multivariate and univariate of variance, follow-up univariate analyses of variance, and *t*-tests with Bonferroni correction and an alpha level of $P < .05$.[22] Results showed that females proved to have 43% less head-neck segment mass and 30% less neck girth than males.[22] Males exhibited 25% less angular acceleration through known trials versus unknown trials, while females had no significant differences between known and known trials.[22] However, there were gender differences in head-neck segment angular acceleration, as females had 70% greater during known trials ($P < .001$) and 31% in unknown conditions ($p = .001$) when compared to males.[22] Angular displacement was 39% greater in females ($P < .001$), indicating a significant gender main effect.[22] Females exhibited 70% more peak muscle activity ($p = .003$) and 117% more muscle activity area ($P < .001$) than males.[22] Muscle onset latency was 29% faster in the SCM ($p = .002$) in females versus males, and females also exhibited 29% less stiffness and 49% less isometric strength than males.[22] These results show massive gender differences in the ability to provide head-neck dynamic stabilization in response to external load, supported by a recent literature review performed on gender differences in concussion occurrence.[23] These findings indicate a highly possible explanation for the differences in concussion rates between gender, as well as an area of discrepancy that could be addressed with a cervical strengthening program.

The adolescent athlete has always presented with special concerns in any injury, including concussions. In a review performed by Kimbler and colleagues, researchers attempt to summarize the association between the occurrence of concussion and participation in youth sports.[24] Statistical trends over the years have revealed that the highest rates of concussion occur in ages 15 – 19,[24] which supports findings presented by Gilchrist et al. in 2011.[1] This age group comprises a significant portion of collegiate athlete, which immediately heightens concerns with concussion in this population.[24] Commonly, concussive symptoms appear to present mildly, which causes younger populations to ignore the need for medical attention,[24] resulting in an increased risk for secondary injury and prolonged symptoms.[6] As mentioned previously, the *Journal of Athletic Training* published an article by Gessel and colleagues that discussed concussions among US high school and collegiate athletes. Concussion represented approximately 9% of all high school injuries and just under 6% of all collegiate injuries, where football and soccer held the highest rates,[21] similar to Marar et al. in 2012 that reported football as the highest and women's soccer coming in second.[11] Consistent with previous findings, collegiate athletes in all sports had higher rates of concussion than high school athletes even though concussions represented a greater percentage of injuries in high school athletics.[21] These findings again place additional concern in the collegiate-level female soccer player.

Age correlated differences have also been documented in the recovery process following concussion. In a study published in the *Journal of Pediatrics,* a comparison of high school and collegiate athletes was performed to determine the differences in recovery following sports-related concussion.[25] A total of 554 athletes underwent baseline neuropsychological examination between the years 1997 to 2000, 183 of which were high school athletes and 371 collegiate athletes.[25] If an individual suffered from a concussion during athletic competition, serial neuropsychological evaluation was then performed.[25] Primary outcomes included a structured interview or history questionnaire, four memory measures, and a Concussion Symptom Scale rating.[25] Individuals included were matched with a control subject according to sport, age, scholastic equivalency, history of diagnosed learning disability, and previous concussion.[25] Statistica software was used for analysis of data. Difference scores for recovery were constructed using post-concussion testing and baseline performance so that a negative value signified a decline from baseline while a positive number signified improvement.[25] Change scores were taken at 24hrs following injury, and three, five and seven days after.[25] MANOVA were performed for scores on standardized memory testing.[25] Primary results revealed high school football and soccer athletes revealed significant memory impairment for a minimum of seven days after injury when compared with matched controls ($P < .04$).[25] As the majority of concussion symptoms resolve within seven to ten days of injury and the final symptom to resolve is usually headache,[5,6] persistent neuropsychological symptoms such as memory impairment pose interest in this young population to minimize concussion recovery.

As soccer has been presented as a high risk sport for concussion, it is important to understand the spectrum of injuries and how they are happening to prompt health care professionals to generate preventative strategies. In a retrospective analysis between the years 1990-2014, The National Electronic Injury Surveillance System was used to collect data on injuries treated in the ER related to the sport of soccer.[26] The specific age range that was targeted was those between 7-17yrs old.[26] The majority of injuries (72.7%) occurred in patients

12-17yrs, with 55.5% occurring in male patients.[26] Primarily, injuries involved sprains or strains, fracture and soft tissue.[26] Although head or neck injuries only comprised 17.7%, and concussions only 7.3% of injuries to this area, the annual rate of concussions took a dramatic leap within the 25yr span of study.[26] From 1990 to 2014, concussion/closed head injuries per 10,000 individuals increased by 1595.6%.[26] These statistics support previous findings by Gilchrist and colleagues in 2011,[1] and the continued search for preventative strategies to thwart this increase in concussion occurrences.

Impacts During Heading

Heading the ball has always been a crucial part of the game of soccer with the ability to shoot, clear, and pass while the ball is still in the air. As female soccer players continue to be identified as a high-risk population for concussions, it is critical to understand cervical muscle activity while heading a soccer ball. In a study published in October 2000, researchers sought to evaluate impact forces on the forehead and the contribution of the cervical musculature linked with different forms of headers in female soccer players.[27] Fifteen female soccer players (average age 20.3 ± 2.3yrs) from the University of Florida were included in this study, with significant experience heading participating at the Division I level.[27] Impact force and muscle activity during passing, clearing and shooting tasks were taken with the Paromed DataLogger and a 15-sensor oval array.[27] Surface electrodes were place over the muscle bellies of both left and right SCM and upper trapezius muscles.[27] Initially, a warm-up was performed and maximal voluntary contractions were recorded in flexion and extension.[27] Six conditions were then performed: passing, clearing, and shooting in both the standing and jumping positions.[27] The ball was delivered by a thrower from 6.5m, and participants were asked to target different positions on the goal based on the randomized condition being performed.[27] Data analysis included measures of central tendency and variability for impulse, impact force, and EMG activity.[27] Additional within-subject ANOVA were performed on peak impact force and impulse, and EMG data from right to left SCM, right to left trapezius, and each type of header. Alpha level was set to .05.[27] Results concluded that the right SCM showed a higher peak normalized EMG while jumping compared to standing headers ($P < .05$), and significant increases in integrated normalized EMG for jumping headers versus standing headers for the right SCM ($P < .01$), right trapezius ($P < .01$), and left trapezius ($P < .01$).[27] Results also revealed that the SCM muscles activate earlier than the trapezius groups before contact with the ball, as well as higher normalized EMG before contact ($P < .05$).[27] The trapezius muscle groups remained active longer than the SCM muscle with higher EMG activity following contact ($P < .05$).[27] The results lead researchers to the conclusion that the cervical musculature during all types of heading are required to propel the ball forward along with stabilize the head and neck to dissipate the impact of force.[27] At this point, it was determined that impact forces at the forehead were not influenced by approach or header type, and that these impact forces were much lower than other contact sports with direct head contact.[27] These results were contradictory to a more recent study by Hildenbrand and Vasavada in 2013 looking at strength in neutral and rotated postures, as they found that rotated postures are predominantly weaker than neutral positions in both males and females, suggesting that soccer players may benefit from training in rotated positions while heading often requires direction change causing different impact forces.[28] These findings support the need for additional research on this topic as these lower forces are still causing concussions, and the neck is a vital part in dissipating those forces.

Dezman, Ledet, and Kerr (2013) performed a similar study, now looking at neck strength imbalances and its correlation to head acceleration, specifically when heading the ball in soccer.[29] Researchers performed this cross-sectional study on 16 collegiate soccer players (eight men and eight women), measuring their neck flexor and extensor strength using a spring-type dynamometer.[29] An individual player was served a ball from the hands of the examiner 20 times from three meters away, having instruction to return the ball to the examiners hands.[29] The player's motions were measured using a 14-camera Vicon MX motion capture system.[29] Variables of focus were translational head acceleration, angular head acceleration, and neck strength.[29] There initial reports showed no differences between sexes in either mean neck flexion or extension.[29] Results showed that when heading the ball, a typical event consists of acceleration of the head into the ball, followed by rapid slowing with impact.[29] It then speeds back up again to hurl the ball, decelerating after the task is completed.[29] With angular head acceleration, there was a positive correlation with mean neck strength difference ($p = .05$), with a slight trend for linear head acceleration ($p = .057$).[29] Their primary conclusion was that reductions in head acceleration were shown with individuals that had similar strength of the neck flexors and extensors.[29] Although these findings do not correlate with previous findings in research, it does pose the question of whether we should be measuring neck strength in soccer players, and trying to promote equal strength in all directions of the neck.[29] With current findings suggesting that impacts to the head may be mitigated by training the neck to be stronger, it is postulated that increasing neck strength can lessen concussion incidence by reducing the severity of head impacts while heading.

Neck Strength

Neck strengthening has become a critical part of high impact sports as a protective mechanism. However, research has yet to come to a definitive conclusion on whether this concept is true for concussions yet. The basis of this idea comes from the theory that a neck strengthening program will cause tangible changes in cervical strength. In a pilot study of 13 male and 13 female recreational high school students (average age 17.6 ± .5yrs), participants underwent an eight-week neck strengthening protocol of low-volume progressive strength training twice per week.[30] Participants would perform neck flexion, extension, and lateral flexion exercises against a plate loaded machine.[30] Protocol involved performing a single set until momentary muscular failure (between 8 – 15 reps) in each direction, with a repetition consisting of a three second concentric contraction followed by a five second eccentric contraction back to neutral.[30] Analysis involved using the Brzycki equation to calculate predicted 1-rep max (1RM) for week one and eight.[30] Paired samples *t*-test comparing the first and last week were used, while independent samples *t*-test compared males and females, and effect sizes were calculated with Cohen's *d* outcome.[30] Results showed that each direction of motion had significant increases in both males and females ($P < .001$ for every direction for both genders).[30] It also revealed that males had significantly greater strength in all directions when compared to females at both weeks one and eight ($P < .001$ in all directions).[30] These results can conclude that even a very low load and very minimally time-consuming program can instill significant increases in neck strength in this young population.[30] Although this study did not directly identify that this lead to reduced concussions, previous research has shown that stronger necks reduce head acceleration, changes in velocity, and displacement that has been postulated to contribute to the risk of concussion.[29, 31]

One study performed in *The Journal of Primary Prevention* sought to develop a tool for measuring neck strength, and to determine if these measurements could then predict the risk for concussion.[20] This study consisted of two stages. The initial stage included five athletic trainers who each took measurements of neck strength in 16 adult subjects using two separate instruments.[20] The second stage then involved a convenience sample within the United States.[20] At this point, they acquired neck length and circumference, as well as measures of strength in flexion, extension, and lateral flexion.[20] Protocols were performed in men's and women's soccer, basketball, and lacrosse teams within the participating schools.[20] Once measurements were taken, they were compared to concussions sustained during the 2010 and 2011 academic years.[20] Their initial reports for gender and sport revealed that soccer had the highest rate of concussion, as well as girls having higher odds, which is consistent with the previous research presented.[11,12] Their primary results concluded that concussed athletes had smaller mean circumferences, and lower overall mean neck strength than those athletes that were uninjured.[20] Results also revealed that sport, gender, and neck strength were each a significant predictor for concussion.

The concept of cervical muscle strength and its effect on head impact has been well studied in recent years. Primarily this research has targeted high impact, contact sports such as football, ice hockey and rugby. Recently, a research question was posed as to whether cervical strength affected head impact biomechanics in youth ice hockey players.[32] There were 37 ice hockey players from a two travel teams between the ages of 13 – 16yrs were included in this study.[32] Data was collected over a span of 98 games and 99 practices within the 2008-2009 season.[32] Main outcomes included head impact telemetry, cervical muscle isometric strength in flexion, rotation, extension, and lateral flexion, upper trapezius strength, and head impact severity.[32] The Head Impact Telemetry System was used to determine head impacts from each incident over the span of the season, using six accelerometers placed within the foam of the helmet, while isometric strength was taken with a handheld dynamometer.[32] Cervical muscle strength was categorized into three groups, allowing researchers to model differences in head impact biomechanics based on levels of strength.[32] Data was transformed to meet assumptions of normality for analysis.[32] Descriptive analyses were used for biomechanical measures of impact severity, linear acceleration, rotational acceleration, and severity profile.[32] Random mixed linear models were performed in STAT and the level of significance was set to $P < .05$.[32] Results were collected for a total of 7770 head impacts, yielding 15 models comparing linear accelerations, rotational accelerations, and head impact telemetry severity profile (HITsp) in relation to muscle strength measurements.[32] There were significant differences noted in the HITsp across the three groups of upper trapezius strength ($P = .037$).[32] Athletes with the strongest upper trapezius experienced greater HITsp when compared to athletes with moderate or low strength, which is a negative effect.[32] There were also no differences found in linear and rotational acceleration among athletes with different neck strengths.[32] This information would contradict previous findings, revealing that greater cervical muscle strength alone cannot reduce sustained impacts.[32] Although results showed that those with weaker trapezius muscles might actually have lower head impact, this may be explained by the fact that stronger players are more willing to go into collisions, especially on open-ice which results in greater rotational acceleration and HITsp measures.[32] Even though these findings do not support current theories on neck strength mitigating head impacts, further studies must be performed to determine if these results can be correlated to other sports.

Additionally, a study published in *The American Journal of Sports Medicine* examined the effects of neck strength and anticipatory cervical activation on the kinematic response of the head when impulsive loads are applied.[31] There was a total of 46 athletes included in this study, all of which were involved in contact sports such as hockey, soccer, football, wrestling, martial arts, and lacrosse.[31] There was a wide variety of age range from eight to thirty years old, with 24 of the participants being male and 22 being female.[31] Researchers noted that they excluded participants if they had previously sustained a concussion.[31] When gathering anthropometric data, girth measurements of the neck and head mass were taken as well.[31] Assessment of maximal isometric neck strength and rate of force development was performed in flexion, extension, left-lateral flexion, and right axial rotation.[31] An in-line force transducer attached to headgear placed on the individuals was used to measure external force application to the head.[31] Finally, head kinematics were taken using a motion capture system with optoelectronic markers placed on the head.[31] Following statistical analysis, results showed significant main effects for neck strength and cervical muscle activation ($P < .001$) in each direction of movement.[31] Significant strength effects remained present when strength-kinematics relationships were assessed in the following directions: sagittal extension, sagittal flexion, and axial rotation.[31] From these results, researchers concluded that greater neck strength, as well as anticipatory muscle activation are associated with attenuation to impulsive force.[31] Results from this article are similar to those found by Gutierrez and colleagues in a more current study,[33] as there were moderate significant findings suggesting a relationship between weaker necks and greater impacts ($P < .05$).[31] Findings would suggest that greater neck strength diminishes the head's dynamic response to external forces, while cervical muscle activation acts independently of neck strength to reduce the response to loading.

While dynamic responses may diminish with greater neck strength, another study performed by Lisman and colleagues attempted to determine the effects of cervical strength training on neck strength, EMG, and head kinematics while performing a football tackle.[34] Sixteen males were included in this study following a physical exam that were college-aged football players (mean age 21.6yrs ± 2.8) with previous high school experience.[34] Inclusion criteria involved no recent history of concussion or neck injury (within the previous six months), could not currently be doing a cervical strengthening program, and must agree to not perform any additional exercises.[34] The cervical resistance training program lasted eight weeks, where the first four weeks included two sessions per week, while the second four weeks increased frequency to three times per week.[34] Each session consisted of three sets of 10 repetitions in extension, flexion, and lateral flexion to both sides with 60 seconds rest between sets.[34] Participants used a weight of 60% of their 10 RM was used to begin, increasing by 5% every two weeks throughout the program.[34] Training was performed on a Pro 4-way neck training machine and a digital force gauge was used to quantify isometric cervical strength.[34] EMG and kinematic responses during a football tackle were assessed at baseline and following the eight-week program.[34] Each individual began in a three-point stance and was given a specific contact point on a dummy to tackle during collection.[34] Participants were instructed on proper tackling technique prior to performing the tackle.[34] EMG activity was assessed by the Noraxon Telemyo System of the right and left sternocleidomastoid (SCM) and upper trapezius (UT) muscles.[34] A ViconNExus was used to gather 3D kinematic data of the upper extremity joints and segments.[34] Statistical analyses were performed using SPSS, with paired-samples *t*-tests for differences in neck girth and cervical strength prior to and following training, ANCOVA for within and between-condition differences in normalized rmsEMG activity, and ANOVA for differences in absolute rmsEMG activity (Bonferroni Test applied for post hoc analysis with repeated measures).[34] Results revealed significant increases in extension ($p = .004$) and left lateral flexion ($p = .033$), and no significant changes in neck girth.[34] There were no significant changes in any kinematic variables (p values from .051-.986).[34] There was no effect on normalized rmsEMG variable, and no significant main/interaction effects for muscle, session, or trial with average linear head acceleration as a covariate (*p* values from .590-.998).[34] There was a statistically significant main effect for muscle ($P < .001$) for absolute rmsEMG activity of both the SCM and UT, with a statistically significant interaction between muscle and session ($p = .014$).[34] These results reveal that although there were some strength increases in extension and left lateral flexion, the experimental program had no influence on kinematic or EMG responses during a normalized football tackle.[34] There are several explanations presented for these results, primarily involving the low intensity of the training regimen and the low range of head accelerations from the impact of a tackling dummy.[34] As the SCM and UT have been described as the primary dynamic stabilizers of the head, it is suggested that a training program with heavier weights and increased training speeds during dynamic stabilization would have greater effects on kinematic and EMG responses.[34] These findings present a need for a conclusive program to improve neck strength to a degree that will impact responses to external load.

In addition to research performed on high collision sports such as football and hockey, studies have delved into the relationship between neck strength and head accelerations during tackles in rugby. In a recent study presented at the International Conference on Biomechanics in Sports, ten elite rugby union players from Australia were recruited to address this topic.[35] Main outcomes included peak isometric neck strength, and head accelerations during a rugby tackle.[35] Neck strength was tested in flexion, lateral flexion, and extension using an HBM 2007 load cell. Head accelerations were taken using markers placed on the player's head, torso and pelvis using a 12 camera 3D analysis during a tackle.[35] The tackle was performed with two defenders from four meters away, where a command would signify the start of the tackle, and contact would be initiated randomly by one of the two defenders.[35] Pearson correlation was used to identify significant relationships between neck strength with head linear and angular accelerations.[35]

Results showed that greater neck flexion strength was correlated significantly to a reduction in range of lateral flexion angular acceleration (r = -.671) and peak medial/lateral acceleration (r = -.911).[35] A decrease in peak medial/lateral accelerations were found to be significantly negatively correlated to increased neck extensor strength (r = -.843) and right lateral flexion strength (r = -.754).[35] Additionally, increased right lateral flexion strength was significantly related to a decrease in peak lateral flexion angular velocity (r = .722).[35] These findings indicated to researchers that an increase in cervical muscular strength was correlated with a decrease in head accelerations, which supports previous studies that promote the use of neck strengthening for reducing concussions.[20] Even though impacts are much greater in rugby than soccer with the inclusion of tackling, it is important to note it is possible that if neck strength can reduce head acceleration with high impact that they may do the same with lower impacts, such as heading a soccer ball.

In 2015, a critical appraisal was performed on the application of neck muscle strengthening in the risk management of concussion in contact sport.[36] Using Ovid MEDLINE, CINAHL, PubMED, EMBASE, and AMED, 13 exclusive articles were included within the first search for the critical appraisal of evidence on neck strength and concussion incidence/risk.[36] Inclusion criteria consisted of those articles that used concussion risk and incidence as outcomes, must be original or systematically reviewed data, and must contribute specific results relating neck strength to concussion incidence, risk or impact kinematics.[36] Following a second search on resistance training programs for cervical musculature, ten articles were included in the appraisal of effectiveness.[36] Inclusion criteria for the second search involved articles that correlated strengthening to neck musculature, rather than to neck pain, or repeated measures within a single session, or healthy controls to clinical populations.[36] Data analyses for quality included the PEDro scale and Newcastle-Ottawa Scale.[36] The level of research evidence was determined using the Oxford Levels of Evidence Scale, and when possible, Cohen's *d*-statistic was calculated to determine the effect size reported between changes in concussion risk, incidence, neck strength, and post-impact head-neck kinematics.[36] Minimum detectable change values ($MDC_{95\%}$) were calculated for strength training programs, when possible to determine the extent of modification necessary for a program to produce a clinically meaningful effect on cervical strength.[36] It was found that total isometric strength within the neck was a significant predictor of concussion occurrence in high school athletics.[36] Though previously reported, peak isometric neck strength does not predict the odds of sustaining a moderate to severe impact to the head.[36] Peak isometric neck strength still may attenuate the kinematic response of the head-neck segment when external forces are applied to the head by anticipatory pre-tensing of musculature, as described in Mihalik et al. (2011) and Schmidt et al. (2014).[19,32,36] Finally, resistance training programs generally produced medium to large effect sizes of change from pre-training to post-training of peak isometric strength.[36] At this point, researchers determined that evidence judiciously supporting the use of neck strengthening to reduce risk of concussion is limited and cannot be recognized for any population, although quality support of short-latency rate of isometric force development has been identified.[36] These conclusions require continued research to make this link more justifiable, and clearly define specific parameters for implementation of a neck strengthening protocol that is both beneficial and safe.

More recently, a pilot study was performed on Division I soccer athletes to determine gender differences in heading kinematics and anthropometrics.[37] Bretzin and colleagues assessed head-neck segment length, mass, and neck girth in 13 soccer athletes (8 female, 5 male).[37] Neck strength was also recorded in all six directions of cervical motion using the

Microfet Hand-Held Dynamometer.[37] While wearing a Gforcetracker accelerometer, the participants were asked to perform 10 headers to a ball (five at 25mph, five at 40mph) delivered by a JUGS machine to simulate a soccer kick; this was performed within a 10-minute period with a one minute break between each header.[37] Data were analyzed using descriptive and interferential statistics.[37] Differences in anthropometrics, strength groups, and head impact kinematics between genders were determined using independent samples *t* tests at the two different ball delivery speeds and a significance level was set at $P \leq .05$.[37] Results revealed significant differences in flexion ($P = .012$) and left lateral flexion ($P = .002$) between males and females, females having weaker strength in both directions.[37] There were also significant differences in rotational velocity between sexes at both 25mph ($P = .024$) and 40mph ($P = .048$) ball delivery speeds.[37] Neck girth and linear acceleration at 25mph ($P = .031$), and rotational velocity at 25mph ($P = .012$) and 40mph ($P = .016$) revealed a significant negative relationship.[37] Significant negative relationships were all also identified between linear acceleration at 25mph and flexors ($P = .011$), left lateral flexors ($P = .031$), and left lateral rotator strength ($P = .034$).[37] Negative correlation was identified at 40mph with flexors ($P = .027$), right ($P = .048$) and left lateral flexors ($P = .030$), and left lateral rotators ($P = .044$).[37] These results provide supporting information to the argument that as cervical strength increases, resulting acceleration from an external force decreases.[17, 22] It also supports the concept that in females with lesser anthropometric measures, head impact kinematics experienced are greater.[17, 22] These findings would suggest that greater anthropometric measurements may increase effective head mass, thus reducing head impact kinematics.[37] Although this sample size was relatively small and cannot be generalized to the greater population, results reveal an increased risk in female soccer players that potentially can be mitigated with a simple neck strengthening protocol.

The question at this point in the research is whether a neck strengthening protocol can effectively provide a preventative mechanism for reducing concussions, and the answer to date is no, not conclusively. Although there is not a definite consensus on this question, viable research has been published that shows some form of relationship between the strength of the neck and it protective nature of the head and brain. If a conclusive definition of concussion could be determined, followed by a neck strengthening program that can effectively stabilize the head to external forces, an effective concussion prevention tool would be within reach. With the presented information in mind, the purpose of this study is to determine whether a neck strengthening or stability program is correlated with changes in concussion rates in NCAA Division I/Division II female soccer teams. The secondary purpose is to identify concussion prevention strategies being utilized within collegiate female soccer teams. A final purpose is to determine perceptions held by ATs on effectiveness of concussion prevention tools.

CHAPTER THREE: METHODS

Design

This was a descriptive study in which data were collected via questionnaire e-mailed to participants through Qualtrics survey software. A reminder was sent out two weeks and four weeks following the initial e-mail to those individuals who had yet to respond. Authorization to carry out this study was approved by the Institutional Review Board at the University of Nevada, Las Vegas. An informed consent form was attached to the first page of the survey, and participants were asked only to continue after reading and agreeing to participation guidelines. Participants could exit the survey at any time.

Sample

The sample represented in this study were ATs employed at an NCAA Division I or Division II university in the United States, and providing services to the university's female soccer team. There are 334 NCAA Division I and 273 Division II universities in the United States with female soccer teams. Of those teams, a response between 15-40% was desired for analytical purposes.

Instrumentation

Data were collected through a Qualtrics survey created to gather information on concussion rates following a cervical strengthening/stability program, concussion prevention strategies being used, and perceptions of prevention methods.

Data Analyses

All calculations were performed using Qualtrics data analysis. Descriptive statistics were used to interpret results of survey questions and were organized by response. Each question was analyzed individually based on the number of responses per question.

CHAPTER FOUR: RESULTS

This survey was sent to a total of 587 NCAA Division I and Division II schools. Of these schools, we received responses from 245 schools (41.7%), 22 of which were excluded as they did not meet inclusion criteria requirements (0.09%). Two-hundred twenty-two responses were used in the analysis of question three. The results revealed that 38 teams (17.12%) are implementing some form of cervical strengthening or stability program for concussion prevention, 177 teams (79.73%) are not, and seven ATs (3.15%) did not know if a program was being implemented (represented in Table 1). Of the 38 universities that were implementing a program, 13 (34.21%) started this program less than one year ago, eight (21.05%) started more than one year but less than two years ago, four (10.53%) started more than two years but less than three years ago, five (13.16%) started more than three years but less than four years ago, two (5.26%) more than four years ago, and six (15.79%) did not know when a program began (represented in Table 2). Twenty-three ATs provided information for the concussion rates the year before and the year after implementation of a cervical strengthening program (represented in Table 3). Ten teams (55.6%) had a reduction in the number of concussions the year after implementation, ranging between one to seven fewer concussions than the year prior. Seven teams (38.9%) suffered the same number of concussions the year prior and the year after implementing a program. One team (0.06%) had one more concussion than the year prior to implementation of a cervical strengthening program. Five ATs were not able to provide information for the year following as they had not yet completed a full fall and spring season since implementing a program.

Of the 219 ATs that responded to question six, 153 (69.86%) believe that a cervical strengthening or stability program will aid in the prevention of concussions, while 66 (30.14%)

do not believe it will prevent concussions (represented in Table 4). Two-hundred seventeen ATs responded with information on other concussion prevention strategies being implemented within the women's soccer team (represented in Table 5 and Table 6). Thirty-six teams (16.59%) are implementing some form of preventative equipment, including recommending the use of mouthpieces, optional headgear, required headgear for athletes with previous concussions, and proper inflation of soccer balls. One-hundred fifty-one teams (69.59%) are implementing education on proper technique to prevent concussions. Fourteen teams (0.06%) are implementing nutritional strategies for concussion prevention including fish oil, omega-3 oils, DHA, magnesium, B12, NAC, D3 supplements, Brain Armor supplements, sleep aids, proper nutritional intake versus calorie expenditure, proper hydration, as well as recommendations of healthy fats (e.g. avocados) and high carbohydrate diets following a concussion. Seventeen teams (0.08%) are implementing other concussion prevention strategies including technique for falling and rolling, vestibular rehabilitation following a concussion, oculomotor training, limitations on the number of headers during training, IMPACT, identification of risk factors (e.g. sleep patterns, hydration, motion sickness), education on concussions and reporting, cervical mobility, sings and symptom education, discussion of smart play (e.g. when the greatest number of concussions occur), and FIFA regulated protocols.

Of the 217 schools that responded to question eight, 19 ATs (8.76%) believe that headgear prevents concussions in soccer, while 198 ATs (91.24%) believe headgear does not prevent concussions (represented in Table 7). Of the 217 schools that responded to question nine, 78 teams (35.94%) have players that wear headgear, ranging from one player to 25 players on a team (represented in Table 8 and Table 9). One-hundred thirty-nine teams (64.06%) do not have any players on the team that wear headgear. Of the 217 schools that responded to question ten, 45 ATs (20.74%) believe that mouth guards prevent concussions in soccer, while 172 (79.26%) believe they do not prevent concussions (represented in Table 10).

Table 1: Survey Question 3

Is/has a cervical strengthening or stability program been implemented within the women's soccer team by you or a member of your staff for the purpose of preventing concussions?	**Number of Responses**
Yes	38
No	177
I don’t know	7

Table 2: Survey Question 4

Do you know when this program was initially implemented?	**Number of Responses**
<1yr	13
>1yr, <2yrs	8
>2yrs, <3yrs	4
>3yrs, <4yrs	5
>4yrs	2
I don’t know	6

Table 3: Survey Question 5

Referring to the INITIAL implementation of a cervical strengthening program, how many concussions were diagnosed in:	**Number of concussions the year prior to implementation**	**Number of concussion the year following implementation**
Respondent 1	2	0
Respondent 2	4	5
Respondent 3	4	4
Respondent 4	1	1
Respondent 5	3	1
Respondent 6	2	2
Respondent 7	4	2
Respondent 8	5	5
Respondent 9	2	2
Respondent 10	3	2
Respondent 11	4	4

Respondent 12	9	2
Respondent 13	5	2
Respondent 14	2	2
Respondent 15	2	1
Respondent 16	7	5
Respondent 17	2	1
Respondent 18	2	1

Table 4: Survey Question 6

Do you believe a cervical strengthening/stability program will aid in concussion prevention in women's soccer teams?	**Number of Responses**
Yes	153
No	66

Table 5: Survey Question 7

Are any other concussion prevention strategies being implemented within the women's soccer team at this time by you or a member of your staff?	**Number of Responses**
Preventative Equipment	36
Education on Proper Technique	151
Nutritional Intervention	14
Other	17

Table 6: Text Responses Survey Question 7 – Concussion prevention strategies being employed

Preventative Equipment	**Nutritional Intervention**	**Other**
mouthpieces recommended	fish oil, Magnesium, B12	Worked with cheer coach on falling and rolling
Unequal halo for training	We provide Brain Armor supplements to those with a history of concussions.	On an individual basis we will do some neck strengthening in high-risk individuals
Strength coach neck strengthening program	DHA, omega-3 oils, NAC	vestibular rehab post-concussion
A few of our players wear padded headbands	proper nutritional intake vs expenditure of calories	Vestibular and Occularmotor Training
Cushioned head strap	Proper nutrition to allow good brain healing. Increased intake of healthy fats such as avocados during healing	Some neck strengthening

head gear, mouthguards	Hydration especially 1-2 hours prior to training	Increased baseline testing for Vestibular System and Occular System
We use the "full 90" for those that are diagnosed with 3 or more concussions while at the university	fish oil with sustained concussions	education on concussions and reporting
One wears one of the protective headguards	Omega 3, Proper nutrition	impact and pre-season education
A few athletes wear headgear	No intervention specifically targeting concussions, but post-concussion care and general health and performance guidelines	We identify risk factors outlined to our staf by Dr Micky Collins out of UP MD, and address the ones we are able. For example, sleep patterns, hydration, eliminating or diminishing motion sickness when able.
Soccer Headgear	We have a sports nutritionist (not related to concussions)	Decreased heading the ball at practice
Full 90's for some athletes with extensive Hx of concussion	nutrition supplementation/sleep aids	Informational sheets were given out at beginning of season with signs and symptoms
Some girls, use headgear, but only about 2-3	Added Omega 3 supplements post concussion (2) athletes that had several concussion previously.	Limit number of head balls taken during practice.
Optional header cap	Proper hydration	Proper heading technique taught by the coaches
some wear halos or head gear	D3 supplements	Reaction time eye training
Athlete's have the choice to wear headgear	fish oil supplements and high carb diet post concussion	Reduced heading at practices
No unless they have had several in the past. Concussion Head band		Education on recognizing concussions and reporting symptoms to staff
Head piece		Discussion of smart play - greatest number of concussions come from physical contact during 50-50 ball challenges
Unequal headbands (if necessary)		FIFA regulated protocols
I have one girl currently who wears a halo and she did not		Online concussion education program prior to each school year

receive a concussion this past year.		
headgear		
Headbands for those with 2+ concussions		
Yes, headgear		
Yes a few players wear protective head gear due to previous concussions		
Two of the athletes wore the protective padded head band.		
Headgear for girls with previous concussion.		
Head gear		
frontal pad		
One athlete is using a full 90 head gear by her/parent's choice		
One athlete wears a Storelli head guard		
Properly inflated balls		
In certain individuals with pre-existing conditions		
Full 90 head gear (2) participants		
headgear/guard		
Previous athletes with history of 2+ concussions are required to wear protective head wear to help prevent another concussion from occurring		
Mouth guards		
Headgear- Neoprene shell with soft padding surrounding the skull.		
one of my athletes wears headgear as added protection.		

Table 7: Survey Question 8

Do you believe headgear prevents concussions in soccer?	**Number of Responses**

Yes	19
No	198

Table 8: Survey Question 9

Do any players on the women's soccer team wear headgear?	**Number of Responses**
Yes	78
No	139

Table 9: Test Responses Survey Question 9 – Number of athletes wearing headgear on team

Text Reported	**Number of Occurrences**
1 now after doctor recommendation	1
1	41
2	20
3	4
3-4	1
4	6
5	1
6	1
10	1
25	1

Table 10: Survey Question 10

Do you believe mouth guards prevent concussions in soccer?	**Number of Responses**
Yes	45
No	172

CHAPTER FIVE: DISCUSSION

The present study aimed to identify strategies that are being used as a concussion prevention tool, identify ATs' perceptions of proposed concussion prevention strategies, and develop a better understanding of neck strengthening and its relationship with changes in concussion rates. Results revealed that more than 17.12% of schools are implementing a cervical strengthening program for concussion prevention. This study reported on the number of concussions the year prior to and following implementation of a neck strengthening protocol. Results supported the need for long-term studies to determine a relationship between cervical strength training and concussion rates, as well as identify confounding factors, mechanism of injury, and concussion severity. Findings also revealed a very large variety of concussion prevention strategies being used, including a wide range of nutritional interventions and protective equipment. Finally, data collection exposed false perceptions of concussion prevention strategies, including ~9% of ATs believing headgear will prevent concussions, and ~20% believing mouth guards will prevent concussions.

Responses revealed several issues with a gap in clinicians' knowledge of preventative equipment. Although only 8.8% of ATs believe that headgear will prevent concussions, 16.59% of respondents specifically mention that staff who implemented protective equipment into the concussion prevention plan. There are 35.9% of teams with athletes who wear some form of headgear, ranging from one to 25 players per team. ATs provided the following responses to preventative equipment being implemented within the team: "Previous athletes with history of 2+ concussions are required to wear protective head wear to help prevent another concussion from occurring," "Headgear for girls with previous concussion," "a few players wear protective head gear due to previous concussions." Analysis of the qualitative responses further support the continued need to educate clinicians and athletes on the best available literature regarding headgear as a protective device.

At this point, evidence does not support the use of protective headgear or mouthguards to prevent concussions, and for the female soccer athlete, evidence suggest that it could be putting them at a greater risk for concussion. Several studies have evaluated the efficacy of equipment for concussion prevention. Daneshvar in 2011 reported on the role of mouth guards and headgear in the prevention of concussion.[38] Superficial wounds, such as lacerations and abrasions to the head, were reduced by wearing headgear, there was no evidence to support its use in mitigating contributing factors of concussion.[38] It also reported that mouth guards have been proven to reduce oral injuries, but do not show evidence for preventing concussions in any sport.[38, 39] A single retrospective survey found that not wearing headgear was associated with a 2.65 greater relative risk of suffering a concussion when compared with those that wore headgear.[39] However, this study lacked validity as the use of headgear was non-randomized, and information provided relied completely on the athlete's ability to recollect events that happened during season.[39] Another systematic review performed by Benson et al. (2009) evaluated protective equipment in concussion prevention.[14] Following evaluation of 51 selected studies for review, they determined that research is inconclusive on the effect of headgear on concussion risk, and there is no strong evidence supporting the use of mouth guards in concussion prevention.[14] Additionally, a meta-analysis and systematic review was performed in 2014 on prevention of sport-related injuries.[16] This meta-analysis reported on three studies that found no preventative effect of headgear or mouth guards on concussion.[16] Surprisingly, in a study performed by Tierney et al. (2008), results revealed that female soccer players exhibited greater head accelerations while wearing headgear (Full 90 and Head Blast Soccer Band) not only when compared to their male counterparts, but also when compared to the control group of females that was not wearing headgear.[17] This information suggests that not only does headgear not mitigate concussion, it potentially increases the severity of contributing factors.

Additionally, 20.7% of ATs believe that mouth guards will prevent concussion in soccer, while 8.76% believe head gear prevents concussions. Mouth guards should be suggested to prevent dental and oral injuries, but not for prevention of concussions.[16, 38] As previously stated, there is no evidence supporting the implementation of headgear or mouth guards to prevent concussions to date.[14, 16, 17, 22, 38] The results of this survey would again suggest a disconnect between practicing ATs and current literature findings. Medical practice standards are constantly changing and it is critical for health care professionals to remain updated to provide accurate information.

With the knowledge of preventative equipment, information reported by Division I and Division II ATs providing coverage to the women's soccer teams is controversial; there is preventative equipment being implemented that has no validity to this point, and can potentially be putting athletes at a greater risk for harm. It is the responsibility of the AT providing coverage to remain up-to-date on current research and implement programs on this basis for the safety of the athletes. Research suggests that until further definitive studies are performed, headgear should be used cautiously by the female soccer athlete.[17]

Perceptions of prevention strategies were also reported by survey respondents. There were 69.86% of ATs who believed cervical strengthening/stability will be effective in preventing concussions in soccer, but only 15% of the 69.86% are implementing any form of neck strengthening program. Therefore, 85% of the ATs who believe a cervical strengthening program will prevent concussions are not employing any form of protocol. There is emerging evidence to support the use of cervical strengthening in female soccer players for concussion prevention.[20, 22, 31, 33, 37] Collins et al. (2014) concluded that there are sex differences in overall neck strength, females being the weaker, and that those with weaker overall neck strength seem to be at a higher risk to suffer from a concussion.[20] A study performed by Eckner and colleagues in 2014 supports these results, finding that greater neck strength and anticipatory cervical muscle activation may reduce the head's kinematic response to external force, which could aid in concussion prevention.[31] Gutierrez et al. (2014) found that when determining the relationship between impact force, neck strength, and neurocognitive performance in soccer heading, specific to adolescent females, there was a significant negative correlation between neck strength and header acceleration; those with weaker necks endure greater impacts.[33] Tierney et al. (2005) determined that females displayed greater head-neck segment peak angular acceleration and displacement when compared to their male counterparts, even though they exhibited earlier muscle activation than males.[22] Finally, the most recent pilot study performed by Bretzin et al. (2016) found that neck strength is a factor that has the potential to limit head impact kinematics.[37] With the current research findings, there is not conclusive evidence to support the use of neck strengthening within the female soccer population; however, it does show significant promise and requires further research. As there is minimal risk with implementing a neck strengthening program, and cervical strength gain requires minimal training,[30] safe concussion prevention strategies could be implemented with little effort. It was surprising that such a large proportion of ATs who believe a cervical strengthening program will aid in preventing concussions and are not utilizing one. It is critical that ATs delve into potential prophylactic strategies for any athletic injury, and implement them in a safe manner as appropriate for the greater good of their athletes.

There were 38 ATs who reported their female soccer teams have implemented a cervical strengthening or stability program. Only 23 were able to provide information, finding that ten teams (55.6%) had a fewer concussions the year after implementation, seven teams (38.9%) suffered the same number of concussions the year prior and the year after implementing a program, and only one team (0.06%) had an increase in the number of concussions the year after a program was started. Although no conclusions can be made from these reports, it does provide compelling information for the need for future research. These data were collected using respondent's self0reported recall of strictly the one year before and one year after implementation. It would be more beneficial to collect concussion rates over a sustained period of time in which a cervical strengthening program was being implemented for several years and concussion data could be taken over that time. This addition would improve validity of information and may reveal accompanying results for the use of a cervical strengthening/stability program in female soccer athletes.

There were several unique prevention strategies reported by Certified Athletic Trainers that are being implemented at the Division I and II level, including varieties of nutritional interventions. Brain Armor Supplement was one of the reported nutritional preventative strategies. This supplement is a plant-based DHA Omega-3 supplement derived from algae, and is meant to promote brain, eye, and heart health.[40] Unfortunately, this is not a Federal Drug Administration regulated product, and there has not been any clinical research that supports its use in the treatment of concussions. Although omega-3 fatty acids have shown some positive results for overall brain development and function, there needs to be additional research performed that dissects its role in concussion prevention as well as recovery.[41] N-Acetyl-Cysteine (NAC) was also reported, which is an amino acid that produces antioxidants within the blood, having anti-inflammatory properties that aid in immune function and cardiovascular health,[42] but has not been studied extensively in the treatment or prevention of concussion. Research performed on sleep aids, magnesium, B12, and vitamin D3 is also limited, as these agents have the most potential to aid in post-concussive issues that arise, but have not been studied for preventing a concussion. Nutritional intervention is an emerging area in concussion prevention and is a potential area of focus in further studies.

As a final point, it is important to note that 3.15% of respondents did not know if a cervical strengthening program was being implemented within their team, and 15.79% did not know when a program had been started. The AT providing primary care to the women's soccer team should be knowledgeable of what protocols are being implemented within their team. These findings place additional importance on the need for effective communication strategies.

Soccer presents itself as a particularly challenging sport to develop preventative tools for concussions as it is one of the few sports where the use of the head is a critical component of successful play; heading the ball is used to challenge an opponent in the air, pass the ball to a teammate, redirect play, or even shoot to score. As concussions are highly prevalent in soccer,[11, 21] especially within the female population,[12, 21] prevention strategies have been progressively integrated into the sport. These methods have included rule changes, education (eg. technique, smart play), protective equipment (eg. headgear, mouth guards), nutritional intervention (eg. omega-3, fish oil), and prophylactic exercise (eg. neck strengthening).[13-16] Unfortunately, findings have been inconclusive as to their effectiveness to prevent concussions, and no preventative tool has been mandated within this athletic population.

Future research must be performed before any conclusions are to be made on current concussion prevention strategies. There is a large variety of prevention strategies being implemented that require greater validity before they can be mandated within the athletic community. With the presented findings of the potential disconnect between current literature and practicing professionals, it is critical to provide evidence-based care and continue to work towards the highest standard of medical practice. This requires thorough communication within the sports medicine staff and supervising athletic staff. The findings of this survey would suggest that there is much progress to be made regarding concussion prevention in women's soccer.

When designing study parameters, possible restrictions were considered and minimized as often as possible. However, limitations of this study design included time constraints of data collection and validity of results. Data was collected over a period of five weeks, but additional findings may have been discovered if collection was extended. Survey studies also make it difficult to draw cause and effect conclusions, which limits the validity of results. It is also difficult to determine accuracy of results as questions were self-reported by supervising ATs, leaving the opportunity for imprecise responses. Following the conclusion of data collection, another limitation was identified for survey questions eight, six, and ten. When ATs were asked if they believed a preventative method would be successful, they were not given an option of "unsure." This may have baited ATs into giving an answer they did not truly believe. There were several considerations deliberated when designing this study to narrow outcomes and ensure that results would be applicable within a clinical setting. This includes targeting a population of athletic trainers working only at NCAA Division I and Division II universities to develop results for high caliber athletes. In addition, ATs supervising the female soccer team were targeted as female soccer players suffer from a high rate of concussions when comparing sport and gender.

Conclusion

In conclusion, there is a surprising disconnect between perceived success of concussion prevention tools and what is reported in the literature. In addition, there is a very wide range of nutritional intervention strategies being utilized that require further investigation of their effects on concussion rates. There is also a large number of schools employing protective equipment for concussion prevention. Finally, several teams have female soccer players wearing headgear at the Division I/Division II level. Although differences were found in concussion rates the year before and the year after implementation of neck strengthening program, further research is required to determine a cause and effect relationship between neck strengthening and changes in concussion rates.

APPENDIX A: SURVEY QUESTIONNAIRE

Q1. Are you a Certified Athletic Trainer at an NCAA Division I or Division II university in the United States?

- Yes
- No

Q2. Are you the primary provider of athletic training services for the female soccer team at your place of employment?

- Yes
- No

Q3. Is/has a cervical strengthening or stability program been implemented within the women's soccer team by you or a member of your staff for the purpose of preventing concussions? (This includes any form of resistive range of motion exercises specifically targeting strength and stability of the neck)

- Yes
- No
- I do not know

Q4. Do you know when this program was initially implemented?

- Less than 1yr ago
- More than 1 but less than 2yrs ago
- More than 2 but less than 3yrs ago
- More than 3 but less than 4yrs ago
- More than 4yrs ago
- I do not know when a program was started

Q5. Referring to the INITIAL implementation of a cervical strengthening program, how many concussions were diagnosed in:
(If a full Fall and Spring season have not yet been completed since starting a neck strengthening protocol, please select NOT APPLICABLE for the year following the start of the program)
The year prior to the start date of the program (Fall and Spring season combined)
0 – 20 / Not Applicable
The year following the start date of the program (Fall and Spring season combined)
0 – 20 / Not Applicable

Q6. Do you believe a cervical strengthening/stability program will aid in concussion prevention in women's soccer teams?

- Yes
- No

Q7. Are any other concussion prevention strategies being implemented within the women's soccer team at this time by you or a member of your staff?
(Select all that apply)

- Preventative equipment (Please provide explanation) ________________________
- Education on proper technique to prevent concussions ________________________
- Nutritional intervention (Please provide explanation) ________________________
- Other (Please provide explanation) _________________________________

Q8. Do you believe headgear prevents concussions in soccer?

- Yes
- No

Q9. Do any players on the women's soccer team wear headgear?
(If so, please provide an estimate of the number of players who wear headgear in the space provided)

- Yes
- No

Q10. Do you believe mouth guards prevent concussions in soccer?

- Yes
- No

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Work Experience

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Athletic Trainer May 2015 - Present

Select Medical, Southwest Athletic Training & Gameday Athletic Training
Responsible for providing athletic training services at special events in the Las Vegas area, and providing substitute coverage at the local high schools.

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Supervisor of approximately thirty lifeguards. Managing and organizing weekly in-service training. Developing budgetary needs and expenses. Promoting safety programs within the community. Developing and administering group and private swim lessons.

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Licensures and Certifications

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