

Concussion-Prevention Strategies Used in National Collegiate Athletic Association Divisions I and II Women's Soccer

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Context: Whereas much attention has been paid to identifying mechanisms for decreasing concussion rates in women's soccer players, which strategies are currently being used is unknown. In addition, athletic trainers' (ATs') knowledge and beliefs about the efficacy of concussion-prevention practices have not been studied.

Objectives: To evaluate the concussion-prevention strategies being used in National Collegiate Athletic Association Division I and Division II women's soccer and identify the beliefs of certified ATs regarding mechanisms for preventing concussion.

Design: Cross-sectional study.

Setting: Online survey.

Patients or Other Participants: A total of 223 women's soccer team ATs employed at Division I or II universities.

Main Outcome Measure(s): A survey instrument of structured questions and open-ended, follow-up questions was developed to identify the use of cervical-strengthening programs, headgear, and other techniques for preventing concussion. Questions also addressed ATs' beliefs regarding the effectiveness of cervical strengthening, headgear, and mouthguards in concussion prevention. Data were collected via questionnaire in Qualtrics survey software. Descriptive statistics

of frequencies and percentages were calculated for close-ended questions. Open-ended questions were evaluated for common themes, which were then reported by response frequency.

Results: Cervical strengthening or stability for concussion prevention was reported by 38 (17.12%) respondents; 153 (69.86%) ATs believed that cervical strengthening would aid in concussion prevention. Seventy-eight (35.49%) reported that their players wore headgear. Nineteen (8.76%) believed that soccer headgear prevented concussions; 45 (20.74%) believed that mouthguards prevented concussions. Education in proper soccer technique was reported by 151 (69.59%) respondents. Fourteen (0.06%) respondents cited nutritional strategies for concussion prevention.

Conclusions: Although ATs believed that cervical strengthening could help prevent concussions, few had implemented this strategy. However, the ATs whose teams used headgear outnumbered those who believed that headgear was an effective prevention strategy. Based on our findings, we saw a disconnect among the current use of concussion-prevention strategies, ATs' beliefs, and the available evidence.

Key Words: headgear, mouthguards, cervical strengthening, mild traumatic brain injury, athletic trainers

Key Points

- Although nearly 70% of collegiate women's soccer athletic trainers (ATs) believed that cervical-strengthening programs would aid in concussion prevention, only 17% currently used such programs.
- More than one-third of ATs reported having an athlete on their team who wore soccer headgear, despite the ATs' lack of belief in the headgear's ability to prevent concussions.
- A disconnect was present between the clinical beliefs of ATs and implementation of concussion-prevention strategies in woman's collegiate soccer players.

Soccer presents a particular challenge for developing concussion-prevention tools because it is one of the few sports in which the physical use of the head is a critical component of successful game play. Heading the ball is used to challenge an opponent in the air, pass the ball to a teammate, redirect play, and even shoot to score. In addition, protective headgear is not a required part of the protective equipment, unlike other sports with potential repetitive exposure to head impacts, such as football and ice hockey. Concussions are prevalent in soccer,^{1,2} especially in the female population.^{1,3,4} Female soccer players have a concussion incidence rate 2.4 times greater than that of male soccer players.³ Most concussions in girls and women

occur from contact with the ball rather than contact with another player or surface.³ In an effort to decrease concussion rates, prevention strategies have been progressively integrated into the sport. These methods have included rule changes, education, protective equipment, and prophylactic exercise.^{5–7} Unfortunately, the findings have been inconclusive as to each intervention's effectiveness in preventing concussion, and no specific prevention tool has been mandated for this population.

Soccer headgear has been marketed to prevent coup mechanisms by providing additional barriers between the head and ball during impact. The use of protective headgear in soccer has paralleled reporting in the mainstream media

on researchers who indicated that newer football helmets may reduce translational and rotational accelerations⁵ and that soccer headgear can decrease peak impact forces.⁸ Although some investigators have shown reductions in peak forces during higher impacts when athletes wear headgear,⁷ the threshold of impact that would result in a concussion is unknown, and concussions are often multifactorial in nature. Female soccer players produced greater head accelerations than their male counterparts while heading with Head Blast headgear (32% more) and Full 90 Select headgear (44% more).⁹ However, in the control condition (wearing no headgear), women heading the ball had a slight, nonsignificant increase (10%) in head accelerations compared with men.⁹ The authors⁹ suggested that adding headgear might actually increase head accelerations during heading, which could increase the potential for and severity of concussion.

Although head accelerations and peak forces are pertinent information regarding the injury mechanism in concussion, limited evidence supports the use of protective equipment for preventing or reducing the concussion risk and incidence.⁵⁻⁷ Protective headgear use in sport does not translate into a reduced incidence of concussion.¹⁰ A recent randomized controlled trial¹¹ in high school soccer athletes showed that the concussion rate and severity were not reduced with the use of headgear. Despite the conflicting findings regarding the biomechanical effects of headgear on header technique in women's soccer⁷⁻⁹ and the lack of evidence supporting protective headgear for preventing concussion,^{5,10-12} whether headgear is being widely used in elite-level play is unknown.

A promising area of research in preventing concussion focuses on the cervical musculature's ability to mitigate aspects of head impacts. Football players with greater cervical stiffness and less angular displacement after an applied perturbation demonstrated decreased chances of sustaining elevated-magnitude head impacts.¹³ Imbalances in neck-flexor and neck-extensor strength ratios in collegiate soccer athletes have been correlated with greater angular acceleration during headers.¹⁴ In addition, neck strength was negatively correlated with header acceleration in high school female soccer athletes.¹⁵ Less overall neck strength has been significantly correlated with concussion rates in basketball, lacrosse, and soccer.¹⁶ Accordingly, researchers^{6,13,16} have indicated that neck-strengthening exercises might be a preventive tool and emphasized the need for further, more definitive research. Neck-strengthening exercises at the team level are commonly implemented in football and other collision-sport training protocols. However, as with the use of headgear, whether collegiate women's soccer teams are implementing cervical-strengthening programs is unknown.

With the information indicating a high risk of concussion in soccer, an increased risk in women and girls, and the potential of neck strengthening as a preventive intervention, we need to evaluate the current use of concussion-prevention strategies in the at-risk population of collegiate women's soccer players. In addition, much of the available research regarding concussion prevention has been published more recently than the often-cited 17-year time period needed to translate research findings into clinical practice.¹⁷ To evaluate the translation of concussion-prevention research into clinical practice in women's soccer, the use of and clinicians' beliefs regarding

concussion-prevention techniques should be evaluated. Therefore, the purpose of our study was to evaluate concussion-prevention strategies used by National Collegiate Athletic Association (NCAA) Division I and Division II women's soccer programs and define their athletic trainers' (ATs') beliefs on the effectiveness of concussion-prevention strategies.

METHODS

Design

This descriptive study was conducted via a questionnaire e-mailed to participants through Qualtrics (Provo, UT) survey software. The study was approved by the university's institutional review board. An informed consent form was included in the first page of the survey. Recruits were asked to continue only after reading and agreeing to the participation guidelines. Continuing to the survey questions was considered participant consent. All questions were optional, and participants could exit the survey at any time.

Participants

Inclusion criteria consisted of being a certified AT employed at an NCAA Division I or Division II university in the United States and considered the primary AT providing medical services to the university's women's soccer team. We chose NCAA universities because we perceived that this athletic conference had a greater likelihood of employing ATs who focused primarily on women's soccer. Division III schools were excluded due to the lack of athletic scholarships. A total of 334 NCAA Division I and 273 Division II universities in the United States had women's soccer teams. Potential participants' e-mail addresses were identified by reviewing publicly available information at the targeted universities' Web sites. If the women's soccer AT's e-mail address was not provided, we contacted the head AT for the university's athletic program to either obtain that contact information directly or forward the survey link to the appropriate AT. Of the 607 universities identified, e-mail contact information was obtained for 587 ATs. To increase response rates, we sent reminders at 2 and 4 weeks after the initial e-mail to those individuals who had yet to respond.

Instrumentation

No survey instrument to evaluate current concussion-prevention methods and ATs' beliefs regarding these methods was available; therefore, we developed a survey for the current study. The survey instrument contained questions in 3 areas: (1) inclusion criteria, (2) current use of concussion-prevention strategies, and (3) ATs' beliefs in the effectiveness of proposed concussion-prevention strategies. Two close-ended questions screened for the inclusion criteria. Two close-ended questions evaluated current cervical-strengthening and headgear practices. The ATs who responded *yes* to current cervical strengthening were prompted to answer a follow-up question regarding how long this practice had been in place. The ATs who responded *yes* to current headgear use among their team were prompted to answer a follow-up question about the number of athletes using headgear. Three close-ended questions identified the ATs' beliefs in cervical strength-

Table 1. Survey Results^a

Item	n	Responses, No. (%)
Is or 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?	222	
Yes		38 (17.12)
No		177 (79.73)
I do not know		7 (3.15)
Do you know when this program (cervical strengthening) was initially implemented?	38	
Less than 1 year ago		13 (34.21)
More than 1, but less than 2 years ago		8 (21.05)
More than 2, but less than 3 years ago		4 (10.53)
More than 3, but less than 4 years ago		5 (13.16)
More than 4 years ago		2 (5.26)
I do not know when a program was started		6 (15.79)
Do you believe a cervical-strengthening and stability program will aid in concussion prevention in women's soccer teams?	219	
Yes		153 (69.86)
No		66 (30.14)
Do any players on the women's soccer team wear headgear?	217	
Yes		78 (35.94)
No		139 (64.06)
Do you believe headgear prevents concussions in soccer?	217	
Yes		19 (8.76)
No		198 (91.24)
Do you believe mouthguards prevent concussions in soccer?	217	
Yes		45 (20.74)
No		172 (79.26)

^a Instrument is presented in its original format.

ening, soccer headgear, and mouthguard use for concussion prevention. A question was also included to assess the clinicians' beliefs that mouthguards prevent concussions; this often-held idea in the athletic community is not evidence based.¹⁸ A final semistructured question provided ATs an opportunity to report any concussion-prevention practices not covered in the close-ended questions.

The first author (K.K.J.) developed the survey with consultation from a committee of experts, including an AT who had previously worked with elite-level women's soccer teams and a statistician. After development, the survey was reviewed by the committee of experts, was pilot tested, and underwent the Qualtrics system's evaluation of clarity and usability. Three pilot-testing participants were directed to give varying responses to evaluate the technical components of the survey (eg, branching questions). The survey consisted of a maximum of 10 questions, depending upon the respondent's previous answers. We projected that the survey instrument could be completed in less than 10 minutes.

Data Analysis

Descriptive statistics of frequencies and percentages reported in the Qualtrics software system were used to interpret the results of the survey questions and were organized by responses. Each question was analyzed individually based on the number of responses.

RESULTS

This survey was sent to ATs at a total of 587 NCAA Division I and Division II schools. Responses were

received from 245 ATs, for a response rate of 41.7%. Twenty-two (0.09%) participants did not meet the inclusion criteria and were excluded. Thus, 223 responses were recorded and analyzed. All questions were optional, so we calculated data and response rates for each question.

Survey results for the close-ended questions are presented in Table 1. The 78 ATs who indicated that a player on their team wore headgear were directed to a follow-up question asking for an estimate of the number of players who wore headgear. Text responses ranged from 1 to 25 players on a team. The number of players on their team who wore headgear was reported as 1 by 42 (53.85%) ATs, 2 by 20 (25.64%) ATs, 3 by 5 (6.41%) ATs, and 4 by 6 (7.69%) ATs. The wearing of headgear by 5, 6, 10, or 25 players was each reported by a single AT (1.28%).

The semistructured survey question, "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?" was answered by 217 ATs. Respondents were allowed to select all options that applied and provide text explanations for 4 response options: (1) preventive equipment, (2) education on proper techniques to prevent concussions, (3) nutritional intervention, and (4) other. Despite the potential for redundancy in responses to the semistructured question and the previous close-ended questions, we evaluated the semistructured question independently. Results of the semistructured question, including text responses, are presented in Table 2. Of note, 7 of the 32 text responses that mentioned the use of soccer headgear as concussion-prevention equipment specifically described headgear use by athletes with a history of concussion. One AT noted that the player wearing headgear

Table 2. Text Responses to the Semistructured Question, “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?”

Option	No. (%)
Preventive equipment	36 (16.59)
Soccer headgear (n = 32)	
Mouthguards (n = 3)	
Education on proper techniques to prevent concussion	151 (69.59)
Education on heading technique (n = 1)	
Education on game management (n = 1)	
Working with the university’s cheerleading coach on falling and rolling techniques (n = 1)	
Nutritional intervention	14 (0.06)
Omega-3 or fish oil (n = 3)	
General nutritional education and caloric intake versus expenditure (n = 3)	
Hydration education (n = 3)	
Docosahexaenoic acid (n = 1)	
Magnesium (n = 1)	
Vitamin B ₁₂ (n = 1)	
N-acetyl-cysteine (n = 1)	
Vitamin D ₃ supplements (n = 1)	
Brain Armor supplements ^a (n = 1)	
Sleep aids (n = 1)	
“Healthy fats” (eg, avocados; n = 1)	
High-carbohydrate diets after a concussion (n = 1)	
Other	17 (0.08)
Vestibular or oculomotor training (n = 4)	
Limiting practice headers (n = 3)	
Education on concussion identification (n = 6)	
Cervical strength and mobility (n = 3)	
Preseason neurocognitive testing (n = 1)	
Proper ball inflation (n = 1)	
Implementing FIFA-regulated protocols (n = 1)	

Abbreviation: FIFA, Fédération Internationale de Football Association.

^a Brain Armor Inc, Brookfield, WI.

on the team was doing so at the recommendation of her physician.

DISCUSSION

We aimed to identify the strategies being used as concussion-prevention tools in NCAA Division I and Division II women’s soccer programs and the ATs’ beliefs regarding select interventions for concussion prevention. Areas of interest were cervical strengthening, use of soccer headgear, and mouthguards for the specific purpose of preventing concussion. With a response rate of 41.7%, our results provide an appropriate evaluation of concussion-prevention strategies in collegiate women’s soccer players.

A cervical-strengthening program for concussion prevention had been implemented by 17.12% of respondent ATs’ soccer teams. Of the 38 respondents who indicated the use of cervical strengthening, more than half (55.26%) stated that the program had been implemented within the past 2 years. The ATs had a high level (69.86%) of belief that cervical-strengthening and -stability programs would be effective in preventing concussions. However, with further analysis, we found that only 23 of the 153 individuals who reported belief in the efficacy of such programs were

working with teams that actually implemented cervical strengthening. It is interesting that a large proportion of ATs believed a cervical-strengthening program would aid in preventing concussions, yet they were not using such a program. Cervical-strengthening programs entail minimal risk, and programs as short as 8 weeks have been shown to increase strength and decrease head velocity.¹⁹ However, the influence of cervical strengthening on concussion rates remains inconclusive and could be sport dependent. Previous researchers^{13,20} observed that neck strength was not associated with concussion rates in contact sports. However, authors^{15,16,21–23} have offered emerging evidence supporting the use of cervical strengthening in female soccer players for preventing concussion. Sex-based differences in neck strength may contribute to the elevated concussion rates in female soccer players, given that those with weaker overall neck strength appeared to be at a higher risk of concussion.¹⁶ Greater neck strength and anticipatory cervical muscle activation has been associated with a reduction in the head’s kinematic response to external force,^{21,22} which may aid in concussion prevention. Females displayed greater head-neck segment peak angular acceleration and displacement than their male counterparts, even though they exhibited earlier muscle activation than males.²³ In adolescent female soccer athletes, neck strength and header acceleration were significantly negatively correlated: those with weaker necks endured greater impacts during heading.¹⁵ In addition, Bretzin et al²¹ determined that soccer players with greater neck strength had decreased linear head accelerations. Although further investigations are necessary to fully evaluate the influence of neck strength on concussion rates, based on our findings, implementation of neck-strengthening protocols in women’s soccer seem to be an emerging practice. However, a disconnect remains between ATs’ belief in cervical strengthening and the implementation of such programs.

Due to soccer headgear being marketed for concussion prevention, the prevalence of its use by NCAA Division I and Division II women’s soccer teams is of interest. More than one third of the ATs reported an athlete on their team wore some form of headgear; the number of athletes per team who wore headgear ranged from 1 to 25 players. Most ATs noted 1 (53.85%) or 2 (25.64%) players using headgear. A disconnect between ATs’ beliefs and implementation was found regarding headgear as well. Although 35.94% of respondents said that a player used headgear, only 8.76% believed that headgear would prevent concussions. This low level of confidence in headgear for preventing concussions is likely a response to the inconclusive literature.^{5–7,11,12} Whereas a single retrospective survey showed that not wearing headgear was associated with a 2.65 times greater relative risk of concussion than wearing headgear, the study lacked validity due to a lack of randomization and the researchers’ reliance on athlete recall of the diagnosis.¹² In a more recent study,¹¹ headgear had no influence on concussion rate or severity. Authors^{5,7,10,24} of systematic reviews and position statements have stressed that research remains inconclusive on the effect of headgear on concussion risk, and limited evidence supports the use of headgear in preventing concussion. In addition, the mechanical properties of headgear may not mitigate impact attenuation during simulated soccer heading.²⁵ Biomechanical evaluations

suggested that headgear could actually put athletes at a greater risk for concussion.⁹ Responses to the open-ended items regarding the use of protective equipment indicated that some athletes wore headgear specifically because of a history of concussion. Respondents provided the following information: “Previous athletes with history of 2+ concussions are required to wear protective headwear to help prevent another concussion from occurring”; “Headgear for girls with a previous concussion”; “a few players wear protective headgear due to previous concussions.” Based on our findings, ATs’ beliefs appeared to be in line with research evidence regarding headgear, but athletes’ beliefs might not align; a third of teams had only 1 athlete each using headgear. Further research is necessary to provide ATs with more definitive evidence for educating patients, particularly those with a history of concussion, on headgear’s ability to prevent concussion (or lack thereof).

Another area of disconnect from the available evidence was mouthguard use for concussion prevention. We found that 20.7% of respondents believed that mouthguards would prevent concussion in soccer players, yet no evidence supports this.^{5,7,10,26} Furthermore, a sports dentistry consensus statement²⁷ stated that mouthguards had not been shown to reduce head impacts. The use of mouthguards should be encouraged to prevent dental and oral injuries, but the evidence does not support their use for preventing concussions.^{10,27} The fact that more ATs (20.7% versus 8.76%) believed in mouthguards than in headgear reflects a disconnect between ATs’ beliefs and the available evidence.

Based on our results from the semistructured question, we identified additional concussion-prevention techniques. Several unique nutritional concussion-prevention strategies were being used, with omega-3 fatty acids mentioned the most. Although researchers²⁸ have shown omega-3 fatty acids offer some benefits for overall brain development and function, additional work is needed to understand omega-3’s role in concussion prevention as well as recovery. Brain Armor Supplement (Brain Armor Inc, Brookfield, WI) was a cited preventive nutritional strategy. This supplement is a plant-based docosahexaenoic acid omega-3 supplement derived from algae and marketed as promoting brain, eye, and heart health.²⁹ N-acetyl-cysteine use was also reported; it has antioxidant-based anti-inflammatory properties proposed to aid in immune function and cardiovascular health.³⁰ N-acetyl-cysteine reduced³¹ symptom severity in military members after a blast-induced mild traumatic brain injury. However, the translation of findings from individuals in an active combat zone to athletes remains to be evaluated. Researchers³² studying other nutritional and pharmacologic interventions have suggested evidence is insufficient to support or refute the use of substances identified in the current study. Nutritional interventions are an emerging area in concussion prevention³³ and a potential area of focus for future investigation.

Limitations

When designing this study, we considered possible restrictions and minimized them where possible. Nevertheless, limitations of this study design include the time constraints of data collection and the validity of the results. Data were collected over a period of 5 weeks, but additional

findings might have been evident if collection had been extended. Survey methods create difficulty in drawing cause-and-effect conclusions, which limits the validity of results. It is also difficult to determine the accuracy of the results, because the answers were self-reported by supervising ATs. Self-reporting permits imprecise responses to occur. Another limitation affected the design of the survey questions. When ATs were asked if they believed a preventive method would be successful, binary responses of *yes* or *no* were the only options, and the respondents were not given an option of *unsure*. This binary response may have forced participants into providing an answer they did not honestly believe. However, answering all questions was optional, and respondents could choose to not answer. Participants’ demographic information was not requested in the survey instrument. Information on years of certification, years of experience working with female soccer teams, and continuing education methods used would have provided insight into the observed disconnect among practice, beliefs, and available evidence. Future studies are needed to evaluate knowledge transfer from research findings to ATs’ clinical practice. We targeted ATs who provided medical care to women’s soccer teams at NCAA Division I and Division II universities. Although we selected this population due to female soccer players’ increased concussion rates when compared across sports and by sex, the ability to translate these findings to other populations is limited. Whether training practices and concussion-prevention strategies differ in women’s and men’s collegiate soccer programs is unknown. We decided to focus on the use of neck strengthening and soccer headgear for preventing concussion; however, we acknowledge that these interventions may have other uses, such as heading-performance benefits or the potential for minimizing the effects of repeated subconcussive impacts from soccer heading.

CONCLUSIONS

Based on our findings, we recognized a disconnect between neck strengthening and headgear use as concussion-prevention strategies currently implemented in NCAA Division I and Division II women’s soccer. ATs’ beliefs in these tools, and the conclusions that can be drawn from the available literature. Whereas nearly 70% of ATs believed that cervical-strengthening programs would aid in concussion prevention, these programs were rarely used. Less than a fifth of respondents reported that cervical-strengthening or stability programs had been implemented for their women’s soccer team. In contrast, more than one third of the respondents indicated use of headgear by at least 1 member of the team, yet more than 90% of ATs did not believe headgear prevented concussion. The ATs’ lack of confidence in headgear as a concussion-prevention tool stemmed from the available literature. Given this disconnect between headgear use and ATs’ beliefs, which were evidence based, we see a need for greater patient education. A surprising finding was that 20% of responding ATs believed that mouthguards prevented concussions. In addition, a wide range of nutritional interventions were used. Overall, future research must be performed before we can draw any conclusions about concussion-prevention strategies. Given the findings of this survey, we suggest that

much progress needs to be made regarding the applications of the research, first to clinical beliefs and then to actual patient implementation.

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