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# Consensus Recommendations on the Prehospital Care of the Injured Athlete With a Suspected Catastrophic Cervical Spine Injury

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***Introduction:*** Sports participation is among the leading causes of catastrophic cervical spine injury (CSI) in the United States. Appropriate prehospital care for athletes with suspected CSIs should be available at all levels of sport. The goal of this project was to develop a set of best-practice recommendations appropriate for athletic trainers, emergency responders, sports medicine and emergency physicians, and others engaged in caring for athletes with suspected CSIs.

***Methods:*** A consensus-driven approach (RAND/UCLA method) in combination with a systematic review of the available literature was used to identify key research questions and develop conclusions and recommendations on the prehospital care of the spine-injured athlete. A diverse panel of experts, including members of the National Athletic Trainers' Association, the National Collegiate Athletic Association, and the Sports Institute at UW Medicine participated in 4 Delphi rounds and a 2-day nominal group technique meeting. The systematic review involved 2 independent reviewers and 4 rounds of blinded review.

***Results:*** The Delphi process identified 8 key questions to be answered by the systematic review. The systematic

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review comprised 1544 studies, 49 of which were included in the final full-text review. Using the results of the systematic review as a shared evidence base, the nominal group technique meeting created and refined conclusions and recommendations until consensus was achieved.

***Conclusions:*** These conclusions and recommendations represent a pragmatic approach, balancing expert experiences and the available scientific evidence.

***Key Words:*** sports, collision athletes, emergency medicine, spine board, log-roll technique

In the United States, sports are among the leading causes of catastrophic *cervical spine injury* (CSI), defined as "a structural distortion of the cervical spinal column associated with actual or potential damage to the spinal cord."[1] There are more than 250 new sport-related CSIs each year.[2] The risk of injury varies among sports. Ice hockey players are among those at highest risk of CSIs.[3] Football is the sport associated with the largest number of CSIs due to the high levels of participation, with more than 1.5 million participants from the middle school through professional levels.[3] Nearly one-quarter of CSIs in children under 15 years of age are sport related, and 85% of sport-related CSIs result in tetraplegia.[2] Appropriate prehospital care of athletes with suspected CSIs can mitigate the significant and long-lasting impacts such injuries have on the health, finances, and quality of life of injured athletes and their families.[4]

There are a number of special organizational and equipment considerations pertaining to optimizing the prehospital care of athletes with suspected CSIs. State and local emergency medical services statutes and guidelines vary. Community sports clubs, high schools, and intercollegiate and professional organizations differ in the available resources, skill levels, and training of rescuers to protect and care for injured athletes. The size of the athlete, weather conditions, space restrictions, and equipment, although important to consider, may not be modifiable. Despite these disparities in resources, providing evidence-based prehospital CSI care is essential for optimizing postinjury outcomes. The development of a set of best-practice recommendations may help organizations without resources to advocate for the additional support needed to provide high-quality care.

The Spine Injury in Sport Group (SISG) was developed to address the evidence that emerged after the 2015 Inter-Association Task Force on Pre-Hospital Care of the Spine-Injured Athlete.[5] The SISG met in Atlanta, Georgia, on March 2–3, 2019, attended by 20 health care professionals with expertise in emergency medicine, sports medicine, neurologic surgery, orthopaedic surgery, neurology, physiatry, athletic training, and research, to review the current literature and discuss evidence-based medicine, best practices, and different options available for the prehospital care of athletes with suspected CSIs. Eleven members had previously served on the Inter-Association Task Force.

The goals of this project were to develop conclusions by summarizing the available evidence and achieve consensus where limited evidence existed and then make recommendations on key concepts of care for athletes with suspected CSIs, with a focus on athletes wearing protective equipment. The target audience includes athletic trainers, emergency responders, sports medicine and emergency physicians, and others caring for athletes with suspected CSIs. The structure of the article is as follows: The "Methods" section describes the processes involved in (1) developing the scope of the systematic review, (2) the systematic review itself, and (3) building of consensus around conclusions and recommendations. The "Results" section describes (1) the specific questions addressed in the review, (2) the findings of the review, and (3) the conclusions and recommendations based on those findings. For ease of reference, the conclusions and recommendations are presented as Table 1. Additional details on phases of the project are available as a Web supplement.

## METHODS

To achieve the multifaceted goals of the project, the National Athletic Trainers' Association, the National Collegiate Athletic Association, and the Sports Institute at UW Medicine engaged the Harborview Injury Prevention and Research Center (HIPRC) as an independent, objective research partner. The HIPRC is an interdisciplinary research center with well-established expertise in injury research, including the use of consensus group methods.[6–13] To address the priorities of the SISG (ie, consensus recommendations on a shared evidence base), the HIPRC research team chose the RAND/UCLA appropriateness method[14] in combination with a systematic literature review. The RAND/UCLA method combines elements of the Delphi and nominal group technique (NGT) approaches for achieving consensus. The 3 stages of the project were (1) identification of the key research questions using a modified Delphi process,[15] (2) a systematic review to assess available evidence, and (3) an NGT in-person meeting[16] to achieve consensus on the conclusions and recommendations regarding the prehospital care of the spine-injured athlete. These stages are described in the following section.

### Stage 1: Delphi Process

The research group used a Web-based modification of the Delphi method of expert consensus building[15] to collect expert opinion and achieve consensus on the target audience, population, and sport for the guidelines and questions for the systematic review. Twenty-one (100%) members of the SISG participated in at least 2 of 4 rounds of iterative online questionnaires over a 2-month period of time. Rounds 1 and 2 (October and November 2018) focused on defining the audience, population, and sports for the guidelines. Rounds 3 and 4 (December 2018 and January 2019) generated questions to be addressed in the systematic review. A full description of the Delphi process, including consensus scores, appears in the Supplemental Material (available online at http://dx.doi.org/10.4085/1062-6050-0434.19.S1).

### Stage 2: Systematic Review

Key terms for the systematic review were based on the 8 questions selected by panelists during the Delphi process. A

trained health sciences research librarian consulted on the terms and search process. Six research databases (PubMed, SPORTDiscus, CINAHL, Web of Science, Embase, and Scopus) and 2 journal archives (*Journal of Athletic Training* and *American Journal of Sports Medicine*) were searched between mid-December 2018 and mid-January 2019. Each data source was queried using identical key words: (*injury*) AND (*spine* OR *spinal* OR *vertebrae* OR *cervical*) AND (*triage* OR *stabilization* OR *assessment* OR *treatment* OR *immobilization* OR *motion restriction* OR *care* OR *screening*) AND (*sport* OR *athlete* OR *athletics*) AND (*Emergency Medical Services* OR *sports medicine* OR *prehospital* OR *emergency medicine*) AND (*equipment* OR *gear* OR *helmet*). Search results were limited to English-language articles with abstracts available. Articles published at any time were included. Two strategies were used to maximize search results. First, related words, equivalent subjects, and full-text searches were conducted when data sources offered those options. Second, we included all studies involving a comparison or control group and did not exclude quasi-experimental or nonrandomized studies.

Two authors (B.M.M., K.M.C.) screened all potential articles, first by titles and then by abstracts using Rayyan software (Qatar Computing Research Institute [Data Analytics], Doha)[17] and prespecified exclusion criteria (see Supplemental Material) to ensure a blinded review. Any disagreements were resolved through consensus. One author (B.M.M.) then reviewed the full text of selected articles while another (K.M.C.) hand searched the references of selected articles for relevant studies that may have been overlooked. When the systematic review identified no relevant articles for a particular question, the 2013 Congress of Neurological Surgeons guidelines[18,19] for the management of acute cervical spine and spinal cord injuries were considered as a "backstop" resource summarizing non–sport-specific spinal injury-care evidence related to prehospital cervical spine immobilization (chapter 2) and transportation (chapter 3). Additional details on the systematic review protocol, including inclusion and exclusion criteria and summary tables, are provided in the Supplemental Material.

### Stage 3: The NGT Consensus Meeting

Results of the systematic review, including reference lists of relevant articles and draft conclusions for each research question, were presented for discussion at the in-person SISG meeting in March of 2019. Questions regarding equipment were divided into subquestions so that conclusions and recommendations regarding face masks could be discussed separately from those regarding helmets and shoulder pads. Draft conclusions were altered and new conclusions were proposed. Using a confidential Web-based voting system, participants scored conclusions on a 1 to 9 scale, where 1 represented *strong disagreement* and 9 represented *strong agreement*. Conclusions with a mean score $<5$ were dropped, and those with a mean score $>7$ were adopted. Conclusions scoring between 5 and 7 were discussed and further votes conducted until consensus was reached. After agreeing on evidence-based conclusions, the group proposed, discussed, and voted on recommendations on the basis of those conclusions using the same confidential scoring process.

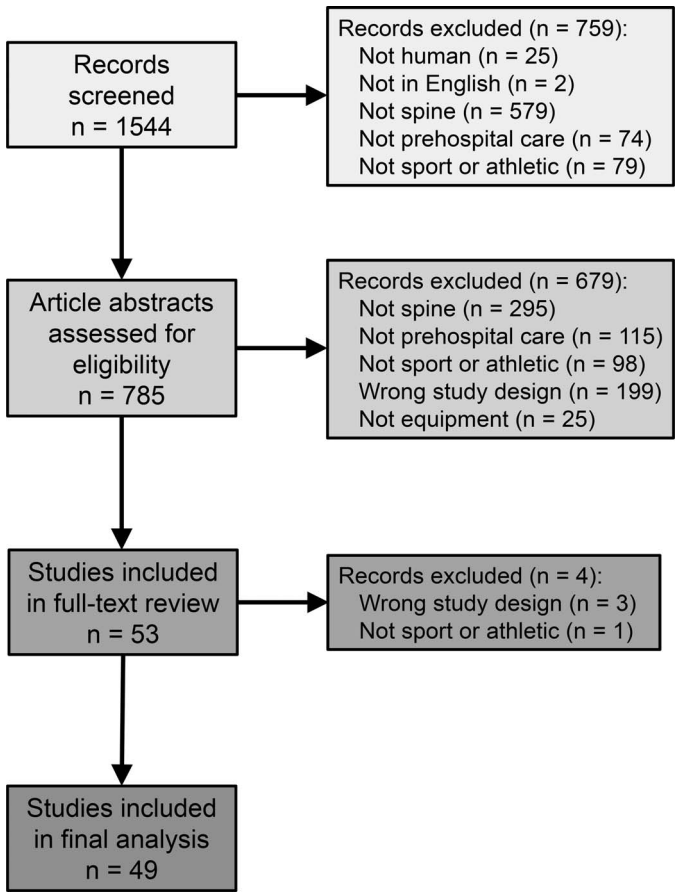


**Figure. Systematic review flowchart.**

## RESULTS

### Stage 1: Delphi Process

All SISG members responded to at least 1 round of the Delphi process; response rates for each round ranged from 71% (round 1) to 90% (rounds 2 and 3). Participants were given 10 to 20 days to respond (depending on the demands of the respective round) and were provided with 1 reminder e-mail. Respondents indicated that sports at all levels (middle school, high school, college, and professional) should be included in the guidelines and that the user audience should include athletic trainers (ATs), team physicians, paramedics or emergency medical technicians, leagues, and coaches (Supplemental Table 1). Because spine injuries without equipment can be handled under local emergency medical services guidelines, it was determined that the systematic review and consensus recommendations would focus on sports involving helmets and body-worn protective gear. Twenty suggested key research questions were condensed into a final set of 8 questions (The questions are reproduced in their original form [Table 2]).

### Stage 2: Systematic Review

Through the comprehensive search strategy, we identified 1544 publications to be screened (Figure). After title,

**Table 1. Prehospital Care of the Injured Athlete With a Suspected Cervical Spine Injury (CSI): Conclusions and Recommendations[a]**
**Continued on Next Page**

| Conclusions | Recommendations |
|---|---|
| **Question 1. What facilities are associated with the best outcomes for an athlete with a suspected CSI?** | |
| Level I and II trauma centers are designated to provide acute urgent care for the most seriously injured and potentially seriously injured patients. | A procedure should be developed to ensure that an athlete with evidence of a spinal column injury is transported to a designated Level I or II trauma center as expeditiously and safely as possible. |
| **Question 2a. Are outcomes after CSI likely to be better when face masks are removed prior to transport?** | |
| Using proper equipment, skilled personnel can remove the face masks of American tackle football players with minimal motion of the cervical spine. | 1) In athletes with suspected CSIs, airway access should be established before transport.<br>2) American tackle football face masks should be removed before transport in athletes with suspected CSI.<br>3) Appropriate tools and trained personnel should be available for face-mask removal. |
| **Question 2b. Are outcomes after CSI likely to be better when the helmet or shoulder pads are removed before transport?** | |
| a) Removal of helmets without concurrent removal of shoulder pads may result in cervical spine malalignment in American tackle football, men's lacrosse, and ice hockey athletes.<br>b) Removal of helmets and shoulder pads creates small but statistically significant amounts of spinal movement in American tackle football, men's lacrosse, and ice hockey players.<br>c) The clinically significant amount of cervical spine motion during equipment removal is unknown.<br>d) Cervical spine alignment is statistically equivalent when the helmet and shoulder pads are on versus when the helmet and shoulder pads have been removed. | 1) The highest priority is maintaining cervical alignment.<br>2) Helmet and shoulder-pad removal should be left to the discretion of trained personnel at the scene.<br>3) If the helmet and shoulder pads are to be removed, the procedures should be done by trained personnel who are competent in equipment removal while minimizing cervical spine motion.<br>4) If the athlete is found with the helmet off and shoulder pads in place, then the head should be supported to maintain cervical spine alignment. |
| **Question 3a. What criteria should be considered when deciding to remove face masks from an athlete with a suspected CSI?** | |
| The research group reached no conclusions regarding specific criteria to consider when deciding whether to remove a face mask. | 1) The highest priority is maintenance of circulation, airway, and breathing (CAB).<br>2) Airway access should be ensured before transport.<br>3) Any athlete with a suspected CSI who is transported should have the face mask removed for airway access.<br>4) The condition of the face mask, specific hardware, available equipment, and training of available personnel should be considered before face-mask removal.<br>5) Care providers should have >1 method available for face-mask removal. |
| **Question 3b. What criteria should be considered when deciding to remove helmet/shoulder pads with a suspected CSI?** | |
| a) When considering helmet and shoulder-pad removal, the highest priority is maintaining CAB.<br>b) Items that can be considered when deciding whether to remove the helmet and shoulder pads:<br>• athlete weight<br>• sport<br>• equipment make and model<br>• types of immobilization devices available | 1) The highest priority is maintenance of CAB.<br>2) Trained personnel should remove the helmet and shoulder pads from athletes with compromised CAB or a decreased level of consciousness.<br>3) When deciding whether to remove the helmet and shoulder pads before transport, the following should be considered: athlete height and weight; the make, model, and condition of the equipment; and the types of immobilization devices available. |
| **Question 4. What method of transfer and spinal-motion restriction (SMR) is associated with the best outcomes for athletes with suspected CSI, both in supine and prone position?** | |
| a) Log-roll–push techniques are superior to log-roll–pull techniques when turning prone injured athletes.<br>b) The 8-person lift and slide results in less spinal movement than the log roll.<br>c) A full-length rigid spine board and full-body vacuum immobilization are equivalent in the degree of cervical spine immobilization. | 1) The highest priority during any transfer technique is maintaining cervical spine alignment.<br>2) The medical professional in charge at the scene must apply clinical judgment to determine the best transfer technique.<br>3) For suspected CSIs, an 8-person lift-and-slide technique for supine athletes and a log-roll–push technique for prone athletes should be implemented during transfer when feasible.<br>4) In supine nonathletes, a scoop stretcher is an acceptable device for minimizing spinal motion.<br>5) To provide the best on-scene care, the medical team should be proficient in multiple transfer techniques.<br>6) The athlete's size may be a factor in selecting the appropriate SMR equipment (ie, standard versus oversized long spine board). |

**Table 1. Continued From Previous Page**

| Conclusions | Recommendations |
|---|---|
| **Question 5. What formal training in the emergency care of an athlete with an on-field suspected CSI is required and recommended?** | |
| Didactic, hands-on, practical, scenario-based training improves the ability of health care personnel to care for an athlete with a suspected CSI. | 1) The highest priority is that all on-site personnel are adequately trained and have rehearsed the techniques necessary to protect the spine of the athlete with a CSI.<br>2) Training should be scenario based and practical, simulate emergency conditions, and encompass all members of the interdisciplinary health care team.<br>3) Venue-specific training and rehearsals (including practice facilities and game sites) should occur at least annually.<br>4) Sports medicine teams should conduct a prepractice and pre-event review of emergency action plans, including equipment, roles, and communication.<br>5) Sports medicine teams should conduct a pre-event "medical time out." |
| **Question 6. When immobilizing the head and neck, is it better to leave the head in the position in which it is found or apply gentle axial distraction to align the head with the cervical spine?** | |
| No conclusions were reached. | 1) The highest priority is maintaining CAB while minimizing cervical spine motion in athletes with suspected CSIs so as to minimize further neurologic impairment.<br>2) Alignment should be sufficient to maintain a patent airway.<br>3) In an awake, responsive, and cooperative athlete, trained medical personnel should employ clinical judgment and discretion before attempting to gently, actively or passively, attain in-line cervical spine stabilization before transport.<br>4) Active spinal manipulation should be avoided if the athlete has impaired consciousness, unless deemed necessary by trained medical personnel to maintain CAB.<br>5) If increased pain, neurologic deterioration, or resistance to movement occurs, cervical spine realignment procedures should be abandoned and the neck stabilized in the current position. |
| **Question 7. How many trained personnel does it take to remove a face mask/helmet/shoulder pads on the field?** | |
| a) No studies have addressed this question regarding face-mask removal.<br>b) The number of people necessary to remove a helmet is unknown.<br>c) Data are insufficient to indicate the number of personnel needed to remove the shoulder pads. | 1) Trained on-site medical personnel should use clinical judgment and discretion in determining the number of people necessary to safely remove the face mask based on its type.<br>2) Ideally, 2 people should be involved in removing the face mask: 1 maintains in-line stabilization and the other removes the face mask.<br>3) Trained on-site medical personnel should use clinical judgment and discretion in considering the equipment design and determining the number of trained personnel necessary to safely remove the helmet and shoulder pads.<br>4) The number of trained personnel recommended to remove the helmet and shoulder pads depends on the equipment, the technique used, and the athlete's size.<br>5) At least 2 trained personnel should be involved in removing the helmet: 1 maintains in-line stabilization and the other removes the helmet.<br>6) For the torso-tilt method, at least 4 trained personnel are needed to remove the shoulder pads. This method should not be used in a patient with a suspected thoracic or lumbar injury.<br>7) For the flat-torso method, at least 2 trained personnel are needed to remove the shoulder pads. |
| **Question 8: Once the athlete with a suspected CSI is moved from the field to the ambulance stretcher, should the spinal-motion restriction equipment be removed before transport or on arrival at the emergency department?** | |
| a) If a cervical collar has been placed on a patient with a suspected CSI, it should stay in place during transport.<br>b) The athlete-specific literature does not address this question.<br>c) Based on nonathlete data, SMR equipment should be left in place for transport of a patient with a suspected CSI.<br>d) Based on nonathlete data, if a long spine board is used, time on the board should be minimized.<br>e) The SMR equipment may include a long spine board, scoop stretcher, Kendrick Extrication Device, vacuum immobilization, cervical collar, straps, head blocks, and tape. | 1) The highest priority is protecting the spine of the athlete with a suspected CSI.<br>2) The decision to transport using spinal precautions should be at the discretion of trained on-site personnel and local emergency medical services.<br>3) If a cervical collar has been placed after a suspected CSI, it should remain during transport.<br>4) If SMR equipment is in place after a suspected CSI, it should remain in place during transport.<br>5) If a long board is used, time on the board should be minimized.<br>6) Once a patient is safely positioned on an ambulance stretcher, transfer or extrication devices may be removed if an adequate number of trained personnel are present to minimize unnecessary movement. Restriction of spinal motion must be maintained. |

[a] Questions are reproduced in their original format.

**Table 2. Delphi-Produced Key Research Questions[a]**

| Question | |
|---|---|
| 1 | What facilities are associated with the best outcomes for an athlete with a suspected CSI? |
| 2a | Are outcomes after CSI likely to be better when face masks are removed prior to transport? |
| 2b | Are outcomes after CSI likely to be better when the helmet/shoulder pads are removed prior to transport? |
| 3a | What criteria should be considered when deciding to remove face masks with a suspected CSI? |
| 3b | What criteria should be considered when deciding to remove helmet/shoulder pads with a suspected CSI? |
| 4 | What method of transfer and spinal-motion restriction is associated with the best outcomes for athletes with suspected CSI, both in supine and prone position? |
| 5 | What formal training in the emergency care of an athlete with an on-field suspected CSI is required and recommended? |
| 6 | When immobilizing the head and neck, is it better to leave the head in the position in which it is found or apply gentle axial distraction to align the head with the cervical spine? |
| 7 | How many trained personnel does it take to remove a face mask/helmet/shoulder pads on the field? |
| 8 | Once the athlete with a suspected CSI is moved from the field to the ambulance stretcher, should the spinal-motion restriction equipment be removed before transport or on arrival at the emergency department? |

Abbreviation: CSI, cervical spine injury.

[a] Questions are reproduced in their original format.



abstract, and full-text screening, 49 articles were included in the final review (Supplemental Figures 1 and 2). The levels of evidence[20] of the included articles varied substantially. Only 1 study was described as a randomized controlled trial (level of evidence 2); a majority of articles involved quasi-experimental designs without randomization (level of evidence 3). A single systematic review was also included. The majority of articles focused on football (78%) or players in the supine position (84%) and did not involve randomization in the study design (Supplemental Tables 2 and 3). Proxy participants took the place of potentially injured athletes in all research. Healthy volunteers participated in a majority of studies (n = 35, 71%), although cadavers and manikins were also studied. Key information and relevance to the specific research questions were extracted from all 49 articles. Sixteen articles were deemed not relevant to the specific research questions. Summary findings, including the number of relevant studies identified, are provided in this section. Tables with individual study characteristics and results are available in the Supplemental Material (see Supplemental Tables 4–10). Conclusions and recommendations are available in Table 1.

Question 1: *What facilities are associated with the best outcomes for an athlete with a suspected CSI?* No relevant sport-related articles addressing this question were identified by the systematic review (N = 0). In the absence of specific sports-related evidence, the Congress of Neurological Surgeons guidelines[19] recommend transport to a specialized, acute spine-injury treatment center whenever possible.

Question 2a: *Are outcomes after CSI likely to be better when face masks are removed prior to transport?* In the systematic review, we found that multiple techniques and removal tools exist; these differ in the time required for removal and the resulting induced motion. No studies directly examined patient outcomes. Studies (N = 4) compared the insertion of a pocket mask with face-mask removal or face-mask removal prior to helmet removal.[21–24] Helmet removal induces significantly more cervical spine motion than does face-mask removal alone. Motion is reduced but time is increased if the face mask is removed before the helmet, although this provides better access to the airway.

Question 2b: *Are outcomes after CSI likely to be better when the helmet/shoulder pads are removed prior to transport?* The systematic review identified studies[22,24–40] (N = 18) of both static cervical alignment and dynamic cervical motion during immobilization in American tackle football, ice hockey, and lacrosse players. No studies directly examined patient outcomes. Comparisons of alignment and motion were made between participants wearing full equipment (helmet and shoulder pads), wearing shoulder pads but no helmet, and wearing no equipment. Studies[27,28,31–34,36,40] involving American tackle football and ice hockey equipment did not indicate statistically significant differences in either static cervical alignment or dynamic cervical motion when comparing participants wearing full equipment with participants wearing no equipment. Removal of the football or ice hockey helmet alone, without removing shoulder pads, resulted in cervical alignment that was statistically significantly different from alignment when not wearing any equipment, with greater cervical lordosis seen when only the helmet is removed.[33–35] However, authors of studies[26,38,39] of lacrosse players (N = 3) disagreed on the difference in cervical alignment between full equipment and no equipment. According to the results of cadaver studies,[28,37] removing only the helmet may lead to more angular displacement in injured spines than is suggested by healthy model studies. For skiers, helmet removal caused significant changes in cervical extension.[29] In the "Discussion" section, we describe in more detail the limitations of these types of comparisons.

Question 3a: *What criteria should be considered when deciding to remove face masks with a suspected CSI?* To identify which criteria should be considered, we looked for studies that examined the influence of personal and situational characteristics on face-mask–removal decisions. Through the systematic review, we found studies (N = 7) comparing both pocket-mask insertion with face-mask removal (n = 3) and face-mask removal with helmet removal (n = 2) as well as equipment and rescuer characteristics.[22,23,41–45] Only 4 criteria were specifically tested for their influence on face-mask removal: equipment design, lighting conditions, hand size of the rescuer, and grip strength of the rescuer. Specific helmet and face-mask designs affect the time for removal and the motion involved in all airway-access techniques, with no clearly superior

design. Lighting conditions, hand size, and grip strength of the rescuer were not found to be significant factors affecting successful removal.[45]

Question 3b: *What criteria should be considered when deciding to remove helmet/shoulder pads with a suspected CSI?* In the systematic review (N = 9), we found that equipment design influenced speed and motion involved in removal.* Deflating helmet bladders did not seem to decrease motion or the difficulty of helmet removal, but it did increase removal time.[42] In contrast to football and ice hockey, in which cervical alignment is closer to neutral when the equipment is on the athlete, in lacrosse, equipment removal may lead to a more neutral alignment. There is no evidence that helmet fit (proper or improper) is a significant factor in cervical spine immobilization.[26,30] Heavier athletes not wearing helmets or shoulder pads experienced less motion on a rigid spine board than when immobilized with vacuum devices.[25] Removing ice hockey helmets before the prone log-roll technique may reduce cervical spine motion.[30]

Question 4: *What method of transfer and spinal-motion restriction is associated with the best outcomes for athletes with suspected CSIs, in both the supine and prone position?* Conducting the systematic review (N = 4), we found that some methods of transfer may involve less cervical spine motion.[25,48–50] Using cadavers, the researchers of 1 study[48] showed that the log-roll push involved less lateral motion than the log-roll pull from the prone into the supine position. Authors of another cadaver study[49] reported that a lift-and-slide technique involved less cervical spine motion than the log roll when starting from a supine position, whereas an 8-person lift involved less motion than the lift-and-slide or log-roll technique. Transfer with either full-body vacuum immobilization or a rigid spine board for athletes in full equipment involved similar amounts of sagittal and frontal angular cervical spine motion, measured as angular motion normalized by time to peak motion (degrees/second).[25] Volunteer athletes did not report a significantly different level of perceived comfort or sense of security during transfer when immobilized with full-body vacuum immobilization or with a rigid spine board.[25]

Question 5: *What formal training in the emergency care of an athlete with an on-field suspected CSI is required and recommended?* Through the systematic review, we determined that whereas pretest training on the techniques studied is included as part of most study protocols, there is very limited research (N = 3) into the content or frequency of training itself.[22,27,46] Frequent training reinforcement and practice can improve speed and reduce head motion.[46]

Question 6: *When immobilizing the head and neck, is it better to leave the head in the position in which it is found or apply gentle axial distraction to align the head with the cervical spine?* In the systematic review, we identified no studies that addressed this question, nor was it addressed in the Congress of Neurological Surgeons guidelines.[18]

Question 7: *How many trained personnel does it take to remove a face mask/helmet/shoulder pads on the field?* Through the systematic review, we found that whereas face-mask removal processes typically involve 1 to 2 people, researchers have not formally compared techniques or outcomes on the basis of the number of people involved in removing the face mask, and only 1 study[51] compared other equipment-removal techniques. Personnel required for removal vary according to the removal technique and the specific athletic equipment being removed.

Question 8: *Once the athlete with a suspected CSI is moved from the field to the ambulance stretcher, should the spinal-motion restriction equipment be removed before transport or on arrival at the emergency department?* In the systematic review, we identified no studies directly addressing this question. The Congress of Neurological Surgeons guidelines[19] consider limiting spinal motion during transport essential. However, all transport may necessitate measures to optimize oxygenation and pulmonary function.

### Stage 3: The NGT Consensus Meeting

Over the course of 2 days, 20 members of the SISG suggested, discussed, and voted on 22 conclusions and 45 recommendations in total. A summary of those conclusions (based on the findings of the systematic review) and recommendations for each question are provided in Table 1. On a scale from 1 (*strong disagreement*) to 9 (*strong agreement*), the mean consensus score among conclusions was 8.24. The mean consensus score among recommendations was 8.01. Full consensus scores for each conclusion and recommendation are included in the Supplemental Material (see Supplemental Table 11).

## DISCUSSION

This project aimed to develop evidence-based guidelines for the prehospital care of the athlete with a suspected CSI. These conclusions and recommendations are intended to provide a structure for conversations around implementing guidelines for prehospital care that are appropriate for the resources, setting, and needs of each care team. A companion article[52] provides more specific information on current best practices for each stage of on-field assessment, emergency care, and transfer of an athlete with a suspected CSI, including emergency action planning, medical time outs, and prehospital versus hospital equipment removal. This article, in contrast, is intended to give readers a more thorough understanding of the underlying issues and questions that should be addressed and the available evidence, even as the specific approaches and practices will vary on the basis of sport, age, level of play, equipment condition, and other varying characteristics of facilities where athletes are at risk of CSIs. It is our intention that these recommendations will be relevant for every type of athletic facility, from small rural high schools with a single coach and volunteer emergency medical services personnel to professional leagues, because best practices for all such organizations include a plan for the prehospital care of an athlete with a suspected CSI as part of their emergency medical action plan. Facilities and medical personnel involved in definitive care for athletes with suspected CSIs may also find these recommendations valuable because prehospital care directly affects hospital care.

A variety of approaches have previously been taken to address the need for standard guidance on prehospital care when an athlete has a suspected CSI. Previously published guidelines have been widely but not universally adopted, and there are important limitations to consider given the

*References 22, 23, 25, 26, 30, 39, 42, 46, 47.

established literature. Because the nature of sports, the demographics of athletes, and injury-care science have changed over time, it is important to review and address changes in all 3 areas. These conclusions and recommendations are based not only on the collective expertise of a highly qualified group of health care professionals but also on a systematic assessment of the available evidence. The consensus-based approach and strictly defined protocol of the literature review were designed to enhance objectivity and reduce bias. Consensus approaches such as the Delphi and NGT are particularly valuable when available evidence is limited and results are mixed. First establishing the areas of agreement (such as the intended audience) and having a shared evidence base available for reference led to productive discussion. Confidential scoring ensured that participants felt comfortable expressing disagreement. Iterative discussion after each round of scoring addressed concerns in real time. Although it remains to be seen how our systematic, consensus-based approach influences the adoption of these recommendations, many participants expressed satisfaction with the strategy as a whole. This approach is also intended to serve as a model for future projects, so that recommendations can be updated as additional evidence becomes available.

The systematic review process highlighted many limitations in the evidence base for a number of the research questions included in this study. A CSI is a rare event, and the majority of studies rely on proxy participants (healthy volunteers, cadavers) and proxy measures (spine alignment, motion, time to equipment removal) that are assumed to be relevant to suspected CSI events. It is unknown how well these proxies represent the reality of an athlete with a suspected CSI. It is not known, for example, what degree of cervical motion in any plane is safe if an individual has a CSI. It is also important to acknowledge the small numbers of participants involved in each study, which may have resulted in studies that were insufficiently powered to detect clinically relevant differences between comparison groups. "No significant difference" should not be interpreted as "no meaningful difference."

Even limited to those sports that involve helmets and body-worn protective gear, there is a great deal of heterogeneity among athletes at risk of a suspected CSI. However, many studies included in the review were limited to American tackle football and examined a very limited number of equipment designs. It is unknown how generalizable the results of these studies are to other equipment designs or other sports or the exact influence of specific equipment design elements on study results. Similarly, most healthy volunteers involved in these studies were young men. In particular, there is a notable lack of studies involving female and adolescent athletes. Most investigations were conducted under laboratory conditions, which may not represent conditions during practice or competitive play.

Although our review protocol may have excluded some relevant studies, it is clear that insufficient research exists on this subject. For several questions, we were unable to identify any relevant studies meeting our review criteria. We encourage researchers and funders to explore the gaps we have identified, including sport-specific studies of athletes of various ages and sizes as well as personnel with varying backgrounds and levels of training.

Athletes, especially those who play sports involving substantial amounts of head and torso protection, are a patient group with unique challenges for health care professionals. Leaving protective equipment in place can affect ambulance transport and hospital-care protocols. The removal of protective equipment is made more challenging by variations in equipment design. The transfer of kinetic energy between players at speed and other physical elements of injury circumstances are quite different from other mechanisms of CSIs. Underlying health, height and weight, and prior injuries of an athlete with a suspected CSI may be substantially different from those of an average patient, and these factors can all affect injury presentation and management.

The devastating consequences of CSIs and the long-term costs that ensue mandate that appropriate resources be devoted to development of a stronger, more rigorous evidence base for the care of athletes with suspected CSIs. Given the resources available in sports, especially at the collegiate and professional levels in the United States, such investment is both feasible and appropriate.

## SUPPLEMENTAL MATERIAL

Supplemental Figures and Tables.

Found at DOI: 10.4085/1062-6050-0434.19.S1.

Spine Injuries in Sports-Managing On-Field Cervical Spine Injuries Produced by the Sports Institute at UW Medicine. Found at: https://www.nata.org/practice-patient-care/health-issues/spine-injury

## REFERENCES

*References 21 through 51 were included in the systematic review.*


1. Banerjee R, Palumbo MA, Fadale PD. Catastrophic cervical spine injuries in the collision sport athlete, part 1: epidemiology, functional anatomy, and diagnosis. *Am J Sports Med*. 2004;32(4):1077–1087. doi:10.1177/0363546504265605
2. 2018 Annual statistical report for the spinal cord injury model systems. National Spinal Cord Injury Statistical Center Web site. https://www.nscisc.uab.edu/public/2018%20Annual%20Report%20-%20Complete%20Public%20Version.pdf. Accessed March 22, 2020.
3. Zahir U, Ludwig SC. Sports-related cervical spine injuries: on-field assessment and management. *Semin Spine Surg*. 2010;22(4):173–180. doi:10.1053/j.semss.2010.06.012
4. Sezer N, Akkuş S, Uğurlu FG. Chronic complications of spinal cord injury. *World J Orthop*. 2015;6(1):24–33. doi:10.5312/wjo.v6.i1.24.
5. Kleiner D, Almquist J, Bailes J, et al. Prehospital care of the spine-injured athlete: a document from the Inter-Association Task Force for Appropriate Care of the Spine-Injured Athlete. Dallas, TX: National Athletic Trainers' Association; 2001:9–10.
6. Kroshus E, Chrisman SP, Harmon KG, et al; National Delphi Panel on Sports Concussion Knowledge. What do parents need to know about concussion? Developing consensus using the Delphi method. *Clin J Sport Med*. November 2018. doi:10.1097/JSM.0000000000000702
7. Lyons VH, Moore M, Guiney R, et al. Strategies to address unmet needs and facilitate return to learn guideline adoption following concussion. *J Sch Health*. 2017;87(6):416–426. doi:10.1111/josh.12510
8. Zumsteg JM, Ennis SK, Jaffe KM, et al. Quality of care indicators for the structure and organization of inpatient rehabilitation care of

children with traumatic brain injury. *Arch Phys Med Rehabil*. 2012;93(3):386–393.e1. doi:10.1016/j.apmr.2011.08.018
9. Rivara FP, Ennis SK, Mangione-Smith R, MacKenzie EJ, Jaffe KM; National Expert Panel for the Development of Pediatric Rehabilitation Quality Care Indicators. Quality of care indicators for the rehabilitation of children with traumatic brain injury. *Arch Phys Med Rehabil*. 2012;93(3):381–385.e9. doi:10.1016/j.apmr.2011.08.015
10. Jurkovich GJ, Rivara FP, Johansen JM, Maier RV. Centers for Disease Control and Prevention injury research agenda: identification of acute care research topics of interest to the Centers for Disease Control and Prevention—National Center for Injury Prevention and Control. *J Trauma*. 2004;56(5):1166–1170. doi:10.1097/01.ta.0000127764.98514.99
11. Burns SP, Rivara FP, Johansen JM, Thompson DC. Rehabilitation of traumatic injuries: use of the Delphi method to identify topics for evidence-based review. *Am J Phys Med Rehabil*. 2003;82(5):410–414. doi:10.1097/01.PHM.0000064739.60860.A7
12. Nathens AB, Rivara FP, Jurkovich GJ, Maier RV, Johansen JM, Thompson DC. Management of the injured patient: identification of research topics for systematic review using the Delphi technique. *J Trauma*. 2003;54(3):595–601. doi:10.1097/01.TA.0000028044.43091.74
13. Rivara FP, Johansen JM, Thompson DC. Research on injury prevention: topics for systematic review. *Inj Prev*. 2002;8(2):161–164. doi:10.1136/ip.8.2.161
14. Humphrey-Murto S, Varpio L, Gonsalves C, Wood TJ. Using consensus group methods such as Delphi and nominal group in medical education research. *Med Teach*. 2017;39(1):14–19. doi:10.1080/0142159X.2017.1245856
15. McPherson S, Reese C, Wendler MC. Methodology update: Delphi studies. *Nurs Res*. 2018;67(5):404–410. doi:10.1097/nnr.0000000000000297
16. McMillan SS, King M, Tully MP. How to use the nominal group and Delphi techniques. *Int J Clin Pharm*. 2016;38(3):655–662. doi:10.1007/s11096-016-0257-x
17. Ouzzani M, Hammady H, Fedorowicz Z, Elmagarmid A. Rayyan: a Web and mobile app for systematic reviews. *Syst Rev*. 2016;5(1):210. doi:10.1186/s13643-016-0384-4
18. Theodore N, Hadley MN, Aarabi B, et al. Prehospital cervical spinal immobilization after trauma. *Neurosurgery*. 2013;72(suppl 2):22–34. doi:10.1227/NEU.0b013e318276edb1
19. Theodore N, Aarabi B, Dhall SS, et al. Transportation of patients with acute traumatic cervical spine injuries. *Neurosurgery*. 2013;72(suppl 2):35–39. doi:10.1227/NEU.0b013e318276edc5
20. Oxford Centre for Evidence Based Medicine Levels of Evidence Working Group. The Oxford 2011 levels of evidence. Oxford Centre for Evidence-Based Medicine Web site. https://www.cebm.net/wp-content/uploads/2014/06/CEBM-Levels-of-Evidence-2.1.pdf. Accessed February 27, 2020.
21. DuBose DN, Connolly S, Hatzel B, et al. Motion created in an unstable cervical spine during the removal of a football helmet: comparison of techniques. *Athl Train Sports Health Care*. 2015;7(6):242–247. doi:10.3928/19425864-20151029-05
22. Waninger KN. Management of the helmeted athlete with suspected cervical spine injury. *Am J Sports Med*. 2004;32(5):1331–1350. doi:10.1177/0363546504264580
23. Swartz EE, Mihalik JP, Decoster LC, Al-Darraji S, Bric J. Emergent access to the airway and chest in American football players. *J Athl Train*. 2015;50(7):681–687. doi:10.4085/1062-6050-50.4.04
24. Endres BD, Swartz EE, Tucker WS, Decoster LC. Head acceleration, time, and difficulty during helmet removal with and without facemask removal. *Athl Train Sports Health Care*. 2015;7(6):224–231. doi:10.3928/19425864-20151029-03
25. Etier BE Jr, Norte GE, Gleason MM, et al. A comparison of cervical spine motion after immobilization with a traditional spine board and full-body vacuum-mattress splint. *Orthop J Sports Med*. 2017;5(12):1–8. doi:10.1177/2325967117744757
26. Petschauer MA, Schmitz R, Gill DL. Helmet fit and cervical spine motion in collegiate men's lacrosse athletes secured to a spine board. *J Athl Train*. 2010;45(3):215–221. doi:10.4085/1062-6050-45.3.215
27. Peris MD, Donaldson WF 3rd, Towers J, Blanc R, Muzzonigro TS. Helmet and shoulder pad removal in suspected cervical spine injury: human control model. *Spine (Phila Pa 1976)*. 2002;27(9):995–999. doi:10.1097/00007632-200205010-00022
28. Palumbo MA, Hulstyn MJ, Fadale PD, O'Brien T, Shall L. The effect of protective football equipment on alignment of the injured cervical spine: radiographic analysis in a cadaveric model. *Am J Sports Med*. 1996;24(4):446–453. doi:10.1177/036354659602400407
29. Murray J, Rust DA. Cervical spine alignment in helmeted skiers and snowboarders with suspected head and neck injuries: comparison of lateral c-spine radiographs before and after helmet removal and implications for ski patrol transport. *Wilderness Environ Med*. 2017;28(3):168–175. doi:10.1016/j.wem.2017.03.009
30. Mihalik JP, Beard JR, Petschauer MA, Prentice WE, Guskiewicz KM. Effect of ice hockey helmet fit on cervical spine motion during an emergency log roll procedure. *Clin J Sport Med*. 2008;18(5):394–398. doi:10.1097/JSM.0b013e31818115e3
31. Metz CM, Kuhn JE, Greenfield ML. Cervical spine alignment in immobilized hockey players: radiographic analysis with and without helmets and shoulder pads. *Clin J Sport Med*. 1998;8(2):92–95.
32. Tierney RT, Mattacola CG, Sitler MR, Maldjian C. Head position and football equipment influence cervical spinal-cord space during immobilization. *J Athl Train*. 2002;37(2):185–189.
33. Treme G, Diduch DR, Hart J, Romness MJ, Kwon MS, Hart JM. Cervical spine alignment in the youth football athlete: recommendations for emergency transportation. *Am J Sports Med*. 2008;36(8):1582–1586. doi:10.1177/0363546508315040
34. Swenson TM, Lauerman WC, Blanc RO, Donaldson WF 3rd, Fu FH. Cervical spine alignment in the immobilized football player: radiographic analysis before and after helmet removal. *Am J Sports Med*. 1997;25(2):226–230. doi:10.1177/036354659702500216
35. Stephenson A, Horodyski MB, Meister K, Kaminski T. Cervical spine alignment in the immobilized ice hockey player: radiographic analysis before and after helmet removal [abstract]. *J Athl Train*. 1999;34(2)(suppl):S27.
36. Decoster LC, Burns MF, Swartz EE, et al. Maintaining neutral sagittal cervical alignment after football helmet removal during emergency spine injury management. *Spine (Phila Pa 1976)*. 2012;37(8):654–659. doi:10.1097/BRS.0b013e31822da067
37. Gastel JA, Palumbo MA, Hulstyn MJ, Fadale PD, Lucas P. Emergency removal of football equipment: a cadaveric cervical spine injury model. *Ann Emerg Med*. 1998;32(4):411–417. doi:10.1016/S0196-0644(98)70168-4
38. Higgins M, Tierney RT, Driban JB, Edell S, Watkins R. Lacrosse equipment and cervical spinal cord space during immobilization: preliminary analysis. *J Athl Train*. 2010;45(1):39–43. doi:10.4085/1062-6050-45.1.39
39. Sherbondy PS, Hertel JN, Sebastianelli WJ. The effect of protective equipment on cervical spine alignment in collegiate lacrosse players. *Am J Sports Med*. 2006;34(10):1675–1679. doi:10.1177/0363546506288849
40. LaPrade RF, Schnetzler KA, Broxterman RJ, Wentorf F, Gilbert TJ. Cervical spine alignment in the immobilized ice hockey player: a computed tomographic analysis of the effects of helmet removal. *Am J Sports Med*. 2000;28(6):800–803. doi:10.1177/03635465000280060601
41. Toler JD, Petschauer MA, Mihalik JP, Oyama S, Halverson SD, Guskiewicz KM. Comparison of 3 airway access techniques during suspected spine injury management in American football. *Clin J Sport Med*. 2010;20(2):92–97. doi:10.1097/JSM.0b013e3181d2de5f

42. Swartz EE, Mihalik JP, Beltz NM, Day MA, Decoster LC. Face mask removal is safer than helmet removal for emergent airway access in American football. *Spine J*. 2014;14(6):996–1004. doi:10.1016/j.spinee.2013.10.032
43. Ray R, Luchies C, Frens MA, Hughes W, Sturmfels R. Cervical spine motion in football players during 3 airway-exposure techniques. *J Athl Train*. 2002;37(2):172–177.
44. Ray R, Luchies C, Bazuin D, Farrell RN. Airway preparation techniques for the cervical spine-injured football player. *J Athl Train*. 1995;30(3):217–221.
45. Burkey S, Jeanmonod R, Fedor P, Stromski C, Waninger KN. Evaluation of standard endotracheal intubation, assisted laryngoscopy (Airtraq), and laryngeal mask airway in the management of the helmeted athlete airway: a manikin study. *Clin J Sport Med*. 2011;21(4):301–306. doi:10.1097/JSM.0b013e31821d314c
46. Lenhardt CS, Mihalik JP, Lynall RC, Fraser MA, Petschauer MA, Swartz EE. The effect of football shoulder pad removal technique and equipment removal training on cervical spine motion, time to task completion, and perceived task difficulty. *Athl Train Sports Health Care*. 2015;7(6):232–241. doi:10.3928/19425864-20151029-04
47. Bric JD, Swartz EE, Al-Darraji SJ, Decoster LC, Mihalik JP. The effects of equipment design on cervical spine motion, removal time, and difficulty during football shoulder pad removal. *J Athl Train*. 2013;48(3)(suppl):S114–S115. doi:10.4085/1062-6050-48.3.s1
48. Conrad BP, Marchese DL, Rechtine GR, Prasarn M, Del Rossi G, Horodyski MH. Motion in the unstable cervical spine when transferring a patient positioned prone to a spine board. *J Athl Train*. 2013;48(6):797–803. doi:10.4085/1062-6050-48.5.07
49. Prasarn ML, Horodyski M, DiPaola MJ, et al. Controlled laboratory comparison study of motion with football equipment in a destabilized cervical spine: three spine-board transfer techniques. *Orthop J Sports Med*. 2015;3(9): 2325967115601853. doi:10.1177/2325967115601853
50. Ransone J, Kersey R, Walsh K. The efficacy of the rapid form cervical vacuum immobilizer in cervical spine immobilization of the equipped football player. *J Athl Train*. 2000;35(1):65–69.
51. Horodyski MB, DiPaola CP, DiPaola MJ, Conrad BP, Del Rossi G, Rechtine GR 2nd. Comparison of the flat torso versus the elevated torso shoulder pad removal techniques in a cadaveric cervical spine instability model. *Spine (Phila Pa 1976)*. 2009;34(7):687–691. doi:10.1097/BRS.0b013e31819794e7
52. Courson R, Ellis J, Herring SA, et al. Best Practices and Current Care Concepts in Prehospital Care of the Spine Injured Athlete in American Tackle Football. J Ath Train. 2020;x(x):xx–xx.

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