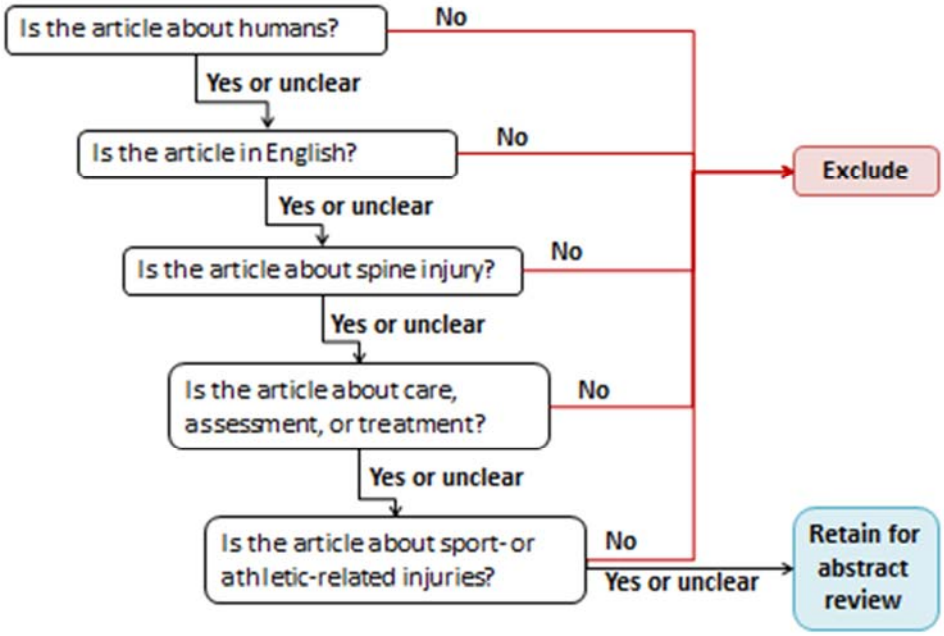
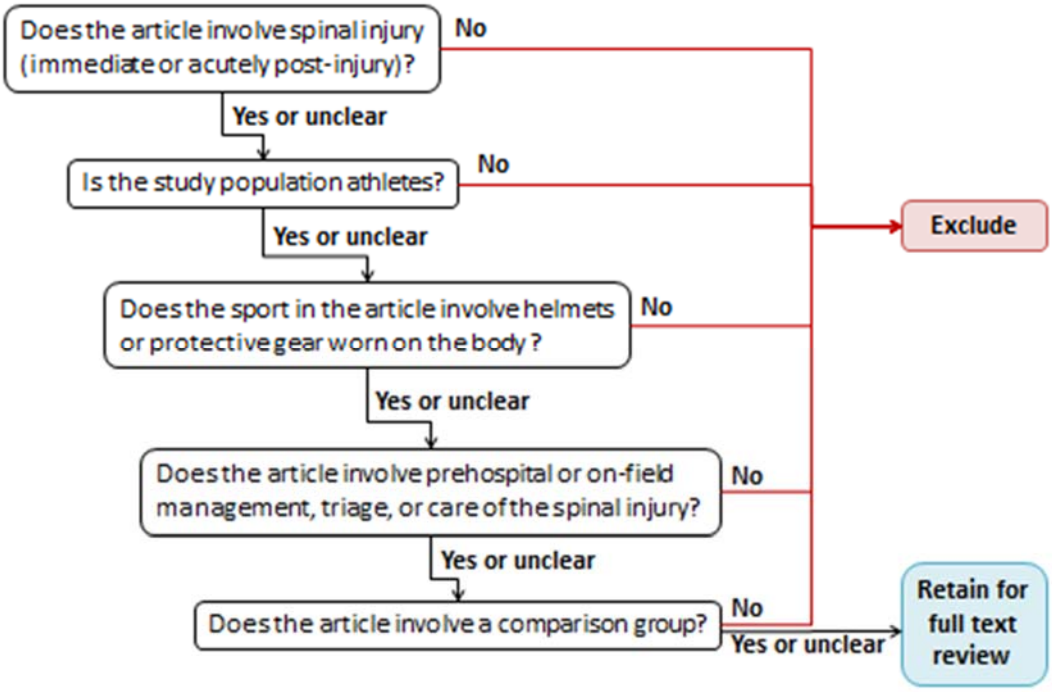
Supplemental Figure 1. Title review protocol



Supplemental Figure 2. Abstract protocol review



Supplemental Table 1. Delphi Consensus Scores[a]

Variable	Score, Mean ± SD	
	Round 1, Scale 1–5	**Round 2, Scale 1–9**
Population		
Middle school	4.06 ± 0.57	NA
High school	4.88 ± 0.34	NA
College	4.46 ± 0.70	8.25 ± 0.83
Professional	4.29 ± 0.57	7.65 ± 1.52
Sport		
Helmeted	4.82 ± 0.34	8.86 ± 0.37
Nonhelmeted	4.03 ± 0.64	NA
Collision	NA	8.29 ± 0.37
Equipment laden	NA	7.71 ± 1.26
Contact	NA	6.86 ± 1.34
All organized sports	NA	5.67 ± 1.17
Target audience		
Athletic trainers	4.74 ± 0.27	NA
Team physicians	4.71 ± 0.46	NA
Paramedics/emergency medical technicians	4.59 ± 0.62	NA
Emergency department providers	4.15 ± 0.97	NA
Leagues (club sports)	3.75 ± 0.73	NA
Coaches	3.56 ± 0.75	NA
Referees	NA	6.84
Parents	NA	5.10

[a] 1 = *strong disagreement*, 9 = *strong agreement*.
Abbreviation: NA, not applicable.

Supplemental Table 2. Systematic Review Search Criteria and Results

Data Source	Search Date	Studies Identified	Includes Related Terms?	Full-Text Search?	Abstract Available?	English Language?
PubMed	1/11/19	335	N	N	Y	Y
SPORTDiscus	1/11/19	75	N	N	Y	Y
Cochrane	12/21/18	53	Y	Y	N	N
CINAHL	1/11/19	41	Y	N	Y	Y
Web of Science	1/11/19	146	N	N	N	Y
Embase	1/11/19	284	N	N	Y	Y
Scopus	1/11/19	715	Y	Y	N	Y
Journal of Athletic Training	1/14/19	68	N	Y	N	N
American Journal of Sports Medicine	1/14/19	55	N	Y	N	N

Abbreviations: Y, yes; N, no.

Supplemental Table 3. Characteristics of Studies Included in Systematic Review (N = 49)

Characteristic	No. of Studies (%)
Sport represented[a]	
American tackle football	38 (78)
Ice hockey	7 (14)
Lacrosse	5 (10)
Downhill skiing	1 (2)
Body position	
Supine	41 (84)
Prone	2 (4)
Seated	1 (2)
Participant type[b]	
Healthy volunteer model	35 (71)
Cadaver	8 (16)
Manikin/dummy	4 (8)
Study design	
Controlled laboratory crossover, not randomized	34 (69)
Controlled laboratory crossover, randomized	10 (20)
Systematic review	2 (4)
Randomized control trial	1 (2)
Cohort	1 (2)

[a] Some studies included more than 1 sport.
[b] When applicable.

The questions in Supplemental Tables 4–11 are reproduced in their original format.

Supplemental Table 4. Summary of Findings for Question 2a, "Are Outcomes After CSI Likely to Be Better When Face Masks Are Removed Prior to Transport?"

Journal	Year	Authors	Study Design	Study Population	Intervention or Exposure	Comparison Groups	Sport	Outcome	Outcome Measurement Type	Results
Athletic Training & Sports Health Care	2015	DuBose et al[21]	Controlled laboratory study	5 cadavers with C5-C6 instability; 2 ATs	Helmet removal	Face-mask removal and then helmet removal vs complete helmet removal	American tackle football	Angular and translational displacement	Electromagnetic motion analysis	Removing the face mask before helmet removal resulted in significantly less flexion-extension, axial rotation, and translational displacement.
Athletic Training & Sports Health Care	2015	Endres et al[24]	Randomized nonblinded crossover study	4 healthy models; 28 ATs	Helmet removal	Two helmet styles, with or without face mask attached	American tackle football	Head acceleration, time to completion, perceived difficulty	Accelerometer, modified Borg CR-10 scale	Removal of face mask before helmet reduced head acceleration but may increase time to completion. No significant differences were found in perceived difficulty.
Journal of Athletic Training	2015	Swartz et al[23]	Randomized nonblinded crossover study	40 ATs	Airway access, chest access technique (face mask removal vs helmet and shoulder-pad removal)	ION 4D vs Riddell 360; ION 4D and traditional pads vs Riddell 360 and Riddell Power with RipKord shoulder pads[a]	American tackle football	Self-rated difficulty, head excursion, time to task completion	8-camera motion caption, modified Borg CR-10 scale	Face-mask removal time was longer for 360 than for ION; helmet removal led to greater motion; no difference in difficulty. Shoulder-pad removal time was shorter with Riddell; no differences in motion or difficulty.
American Journal of Sports Medicine	2004	Waninger[22]	Scoping review	54 studies, including surveys and case reports	On-field and ED care of athletes with suspected CSI	NA	NA	NA	NA	Evidence remains moderately circumstantial and anecdotal. Keeping equipment in place has not been found to be detrimental. Adequate data on pediatric and female athletes and breadth of equipment designs were not available.

Abbreviations: AT, athletic trainer; CSI, cervical spine injury; ED, emergency department; NA, not applicable.
[a] ION 4D; Schutt Sports, Litchfield, IL; Riddell 360 and Power; Des Plaines, IL.

Supplemental Table 5. Summary of Findings for Question 2b: "Are Outcomes After CSI Likely to Be Better When the Helmet/Shoulder Pads Are Removed Prior to Transport?"

Journal	Year	Authors	Study Design	Study Population	Intervention or Exposure	Comparison Groups	Sport	Outcome	Outcome Measurement Type	Results
Spine	2012	Decoster et al[36]	Crossover study	20 male participants; 3 ATs	Helmet removal	Helmet vs no helmet or towel vs no helmet with towel vs no helmet with towel after 20 min	American tackle football	Cobb angle measurements	Collimator x-ray machine (radiography)	No significant differences in cervical lordosis between full equipment and any helmet-removed conditions. Time since towel placement was not significant. Towel-support conditions had significantly less cervical lordosis than no towel.
Athletic Training & Sports Health Care	2015	Endres et al[24]	Randomized nonblinded crossover study	4 healthy models; 28 ATs	Helmet removal	Two helmet styles, with and without face mask attached	American tackle football	Head acceleration, time to completion, perceived difficulty	Accelerometer, modified Borg CR-10 scale	Removal of face mask before helmet reduced head acceleration but may increase time to completion. No significant differences in perceived difficulty.
Orthopaedic Journal of Sports Medicine	2017	Etier et al[25]	Crossover study	20 male participants in 4 weight groups; 7 staff (2 ATs, 3 sports med ortho fellows, 2 sports med ortho surgeons)	Immobilization and equipment removal	(1) Rigid spine board vs full-body vacuum splint; (2) helmet and shoulder pads vs no equipment; (3) weight group	American tackle football	Peak planar cervical spine motion, perception of comfort and security	Electromagnetic motion analysis	Small but significant differences in cervical motion were noted between immobilization types under various test conditions. Body weight was associated with motion under a variety of test conditions.
Annals of Emergency Medicine	1998	Gastel et al[37]	Crossover study	8 cadavers	Equipment removal	No equipment vs helmet only vs helmet and shoulder pads vs shoulder pads only; intact vs injured spine	American tackle football	Angular displacement, dorsal element distraction, posterior disc space height, sagittal plane translation at C5-C6	Radiography	No significant difference in any parameter among the 4 equipment conditions before dislocation procedure. Postinjury, significant differences between the helmet-only condition and other equipment conditions. Differences between preinjury and postinjury were only significant for the helmet-only condition
Journal of Athletic Training	2010	Higgins et al[38]	Crossover study	10 collegiate lacrosse athletes	Equipment removal	No equipment vs shoulder pads only vs shoulder pads and helmet	Lacrosse	Space available for the cord (SAC), cervical-thoracic angle (CTA)	Magnetic resonance imaging	No difference in SAC across the 3 groups. CTA was greater for shoulder pads than no equipment. No difference in CTA between the no-equipment and full-equipment conditions.
American Journal of Sports Medicine	2000	LaPrade et al[40]	Crossover study	10 male participants	Equipment removal	No equipment vs helmet and shoulder pads vs shoulder pads only	Ice hockey	cervical kyphosis or lordosis	Computerized tomography lateral scout scan	Removal of the helmet alone resulted in significantly greater cervical lordosis than either full equipment or no equipment. This lordosis was mainly at the C6-C7 level.

Clinical Journal of Sport Medicine	1998	Metz et al[31]	Crossover study	8 healthy male participants	Equipment removal	No equipment vs helmet and shoulder pads vs shoulder pads only vs helmet only	Ice hockey	Cobb angle	Radiography	No significant difference between no-equipment and full-equipment conditions. Cervical lordosis in the shoulder-pads only condition was significantly greater than either no or full equipment.
Clinical Journal of Sport Medicine	2008	Mihalik et al[30]	Crossover study	18 adult male hockey players	Prone log roll	Competition helmet vs no helmet vs properly fit helmet	Ice hockey	Head-to-thorax and helmet-to-thorax motion during prone log roll.	Electromagnetic motion analysis	Increased cervical spine motion (head-to-thorax) occurred when helmet was not removed. No significant different in cervical spine motion between helmet fit types.
Wilderness & Environmental Medicine	2017	Murray et al[29]	Non-randomized crossover	28 volunteer skiers	Helmet removal	Helmet vs helmet with cervical collar vs no helmet with cervical collar	Downhill skiing	Change in cervical spine alignment, time to helmet removal and stabilization	Radiography	Compared with helmeted without a collar, placing a collar with or without removing the helmet resulted in significant changes in cervical extension.
American Journal of Sports Medicine	1996	Palumbo et al[28]	Controlled laboratory study	15 cadavers	Equipment removal	No equipment vs helmet only vs shoulder pads only vs helmet and shoulder pads	American tackle football	Cervical lordosis, C5-C6 angular displacement, posterior element distraction, disc space height, sagittal plane translation	Radiography	Outcomes in full equipment did not differ significantly from outcomes in the no-equipment condition for both intact and destabilized spines.
Spine	2002	Peris et al[27]	Controlled laboratory study	7 male participants; 4 research staff	NATA protocol for removal of equipment	Before removal vs during elevation vs after helmet removal vs after shoulder pad removal vs no equipment	American tackle football	Angulation C2-C6, disc height at C2-C3, translation at C5-C6, SAC	Digital fluoroscopy	No significant change in disc height, translation, or SAC. No significant motion in angulation.
Journal of Athletic Training	2010	Petschauer et al[26]	Crossover study	18 collegiate men's lacrosse players	Helmet fit	Fitted helmet vs improperly fitted helmet vs no helmet	Lacrosse	Voluntary head range of motion	Electromagnetic motion analysis	Range of motion was greater with a helmet, but there was no significant difference between the types of helmet fits.
American Journal of Sports Medicine	2006	Sherbondy et al[39]	Crossover study	16 NCAA Division I male lacrosse players	Equipment removal	Helmet and shoulder pads vs shoulder pads only vs no equipment	Lacrosse	Cervical spine alignment in sagittal plane	CT scan	Significant difference in overall cervical spine alignment between full equipment and no equipment. Significant difference in C0-C2 alignment between full equipment and shoulder pads only. Significant difference in C2-C7 alignment between shoulder pads only and no equipment.
Journal of Athletic Training	1999	Stephenson et al[35]	Crossover study	13 male ice hockey players	Equipment removal	No equipment vs helmet and shoulder pads vs shoulder pads only	Ice hockey	Sagittal cervical alignment	Radiography	Removing the helmet resulted in significantly different C0-C2 and C2-C7 angles compared with either full equipment or no equipment.

American Journal of Sports Medicine	1997	Swenson et al[34]	Crossover study	10 male participants	Equipment removal	No equipment vs helmet and shoulder pads vs shoulder pads only	American tackle football	Sagittal cervical alignment	Radiography	No significant differences between no-equipment and full-equipment conditions. Removal of helmet alone resulted in significantly increased cervical lordosis.
Journal of Athletic Training	2002	Tierney et al[32]	Crossover study	12 male participants	Equipment removal	0, 2, and 4 cm occiput elevation without helmet and shoulder pads vs helmet and shoulder pads	American tackle football	SAC, sagittal diameter, CTA	Magnetic resonance imaging	SAC was significantly greater for the equipment condition and 0-cm elevation than for other conditions. There was no significant difference between 0-cm elevation and the equipment condition.
American Journal of Sports Medicine	2008	Treme et al[33]	Crossover study	31 male athletes, aged 8–14 y	Equipment removal	No equipment vs shoulder pads only vs shoulder pads and helmet	American tackle football	Cervical lordosis based on Cobb angle, subaxial angle	Radiography	Significantly greater cervical lordosis with shoulder pads only, compared with other conditions. No significant difference seen between the no-equipment and full-equipment conditions.
American Journal of Sports Medicine	2004	Waninger[22]	Scoping review	54 studies, including surveys and case reports	On-field and ED care of athletes with suspected CSI	NA	NA	NA	NA	Evidence remains moderately circumstantial and anecdotal. Keeping equipment in place has not been found to be detrimental. Adequate data on pediatric and female athletes and breadth of equipment designs not available.

Abbreviations: AT, athletic trainer; CSI, cervical spine injury; CTA, cervical-thoracic angle; ED, emergency department; NA, not applicable; NATA, National Athletic Trainers' Association; NCAA, National Collegiate Athletic Association; ortho, orthopaedic; SAC, space available for the cord.

Supplemental Table 6. Summary of Findings for Question 3a: "What Criteria Should Be Considered When Deciding to Remove Face Masks With a Suspected CSI?"

Journal	Year	Authors	Study Design	Study Population	Intervention or Exposure	Comparison Groups	Sport	Outcome	Outcome Measurement Type	Results
Clinical Journal of Sport Medicine	2011	Burkey et al[45]	Randomized nonblinded crossover study	42 resident physicians	Airway access and lighting conditions	Assisted intubation, laryngeal mask, standard intubation	American tackle football	Airway access, time to airway access	Not specified	No difference in difficulty under bright lights for any approach. 50-50 split opinion on standard or LMA being easiest. LMA was slightly faster, 23 vs 36 s ($P < .001$).
Journal of Athletic Training	1995	Ray et al[44]	Partial crossover	12 NCAA Division III football players	Airway access	Face mask removal via manual screwdriver vs power screwdriver vs Trainer's Angel cutting tool vs insertion of pocket mask	American tackle football	Helmet motion	Optotrak 3020 optoelectronic motion-analysis system[a]	Trainer's Angel induced significantly more motion than other methods. Pocket mask required less time.
Journal of Athletic Training	2002	Ray et al[43]	Crossover study	12 NCAA Division III football players; 2 senior athletic training students	Airway access	Pocket mask via chin insertion vs pocket mask via eyehole insertion vs face-mask rotation using screwdriver	American tackle football	Cervical spine motion, time	Optoelectronic motion analysis system (Optotrak)	Face-mask rotation took significantly longer than pocket-mask insertion. There was no significant difference in cervical spine rotation across the 3 techniques. Eyehole insertion produced the least motion but not always to a significant degree.
The Spine Journal	2014	Swartz et al[42]	Crossover study	22 certified athletic trainers	Airway access	Face-mask removal vs helmet removal with and without bladder deflation	American tackle football	Head motion, removal time, difficulty	6-camera motion caption, modified Borg CR-10 scale	Face-mask removal resulted in less motion and shorter time than helmet removal. Riddell Revolution IQ helmet removal resulted in less frontal motion and quicker removal than Riddell VSR helmet removal. Deflation increased removal time but did not significantly alter motion or difficulty.
Journal of Athletic Training	2015	Swartz et al[23]	Randomized nonblinded crossover study	40 athletic trainers	Airway access, chest-access technique (face mask removal vs helmet and shoulder-pad removal)	ION 4D vs Riddell 360; ION 4D and traditional pads vs Riddell 360 and Riddell Power with RipKord shoulder pads[b]	American tackle football	Self-rated difficulty, head excursion, time to task completion	8-camera motion capture, modified Borg CR-10 scale	Face-mask removal time was longer for 360 vs ION; helmet removal led to greater motion; no difference in difficulty. Shoulder-pad removal time was shorter with Riddell; no differences in motion or difficulty.

Clinical Journal of Sport Medicine	2010	Toler et al[41]	Crossover study	1 healthy model; 36 participants (18 certified athletic trainers, 18 noncertified athletic training students)	Airway access	Quick-release mechanism vs cordless screwdriver vs pocket mask insertion; certified AT vs noncertified AT students	American tackle football	Time to airway access, head movement	Electromagnetic motion capture	Pocket-mask insertion was fastest technique and involved less motion in the frontal plane. Results were similar regardless of certification. Motion differed between head measures and helmet measures. No significant differences between athletic trainers and students.
American Journal of Sports Medicine	2004	Waninger[22]	Scoping review	54 studies, including surveys and case reports	On-field and ED care of athletes with suspected CSI	NA	NA	NA	NA	Evidence remains moderately circumstantial and anecdotal. Keeping equipment in place has not been found to be detrimental. Adequate data on pediatric and female athletes and breadth of equipment designs not available.

Abbreviations: CSI, cervical spine injury; LMA, laryngeal mask airway; NA, not applicable; NCAA, National Collegiate Athletic Association.
[a] ION 4D; Schutt Sports, Litchfield, IL; Riddell 360 and Power; Des Plaines, IL.
[b] Optotrak 3030; NDI, Waterloo, ON, Canada.

Supplemental Table 7. Summary of Findings for Question 3b: "What Criteria Should Be Considered When Deciding to Remove Helmet/Shoulder Pads With a Suspected CSI?"

Journal	Year	Authors	Study Design	Study Population	Intervention or Exposure	Comparison Groups	Sport	Outcome	Outcome Measurement Type	Results
Journal of Athletic Training	2013	Bric et al[47]	Controlled laboratory study	1 healthy model; 40 ATs	Shoulder-pad removal technique	Traditional vs quick-release design	American tackle football	Cervical spine motion, removal time, perceived difficulty	3-dimensional motion capture	There were no significant differences in motion or perceived difficulty. Quick-release pads required significantly less time to remove.
Orthopaedic Journal of Sports Medicine	2017	Etier et al[25]	Crossover study	20 male participants in 4 weight groups; 7 staff (2 ATs, 3 sports med ortho fellows, 2 sports med ortho surgeons)	Immobilization and equipment removal	(1) Rigid spine board vs full-body vacuum splint; (2) helmet and shoulder pads vs no equipment; (3) weight group	American tackle football	Peak planar cervical spine motion, perception of comfort and security	Electromagnetic motion analysis	Small but significant differences in cervical motion were noted between immobilization types under various test conditions. Body weight was associated with motion under a variety of test conditions.
Athletic Training & Sports Health Care	2015	Lenhardt et al[46]	Randomized nonblinded crossover study	Unspecified models; 31 certified ATs, 1 senior student	Shoulder pad removal technique	Elevated torso with traditional shoulder pads vs flat torso with traditional shoulder pads vs Riddell RipKord pad removal[a]	American tackle football	Head motion, time to removal, perceived difficulty	Electromagnetic motion capture; modified Borg CR-10 scale	Riddell RipKord removal was faster than other techniques, rated as less difficult. No significant different was noted in head motion across the techniques. Reinforced training improves speed and decreases range of head motion.
Clinical Journal of Sport Medicine	2008	Mihalik et al[30]	Crossover study	18 adult male hockey players	Prone log roll	Competition helmet vs no helmet vs properly fit helmet	Ice hockey	Head-to-thorax and helmet-to-thorax motion during prone log roll	Electromagnetic motion analysis	Increased cervical spine motion (head to thorax) occurred when helmet was not removed. No significant different in cervical spine motion between helmet fit types.
Journal of Athletic Training	2010	Petschauer et al[26]	Crossover study	18 collegiate men's lacrosse players	Helmet fit	Fitted helmet vs improperly fitted helmet vs no helmet	Lacrosse	Voluntary head range of motion	Electromagnetic motion analysis	Range of motion was greater with a helmet, but there was no significant difference between the types of helmet fits.
American Journal of Sports Medicine	2006	Sherbondy et al[39]	Crossover study	16 NCAA Division I male lacrosse players	Equipment removal	Helmet and shoulder pads vs shoulder pads only vs no equipment	Lacrosse	Cervical spine alignment in sagittal plane	CT scan	Significant difference in overall cervical spine alignment between full equipment and no equipment. Significant difference in C0-C2 alignment between full equipment and shoulder pads only. Significant difference in C2-C7 alignment between shoulder pads only and no equipment.

Journal of Athletic Training	2015	Swartz et al[23]	Randomized nonblinded crossover study	40 ATs	Airway access, chest access technique (face mask removal vs helmet and shoulder pad removal)	ION 4D vs Riddell 360; ION 4D[b] and traditional pads vs Riddell 360 and Riddell Power with RipKord shoulder pads	American tackle football	Self-rated difficulty, head excursion, time to task completion	8-camera motion capture, modified Borg CR-10 scale	Face-mask removal time was longer for 360 vs ION. Helmet removal led to greater motion; no difference in difficulty. Shoulder-pad removal time was shorter with Riddell; no differences in motion or difficulty.
The Spine Journal	2014	Swartz et al[42]	Crossover study	22 certified ATs	Airway access	Face mask removal vs helmet removal with and without bladder deflation	American tackle football	Head motion, removal time, difficulty	6-camera motion capture, modified Borg CR-10 scale	Face-mask removal resulted in less motion and shorter time than helmet removal. RIQ helmet removal resulted in less frontal motion and quicker removal than VSR helmet removal. Deflation increased removal time but did not significantly alter motion or difficulty.
American Journal of Sports Medicine	2004	Waninger[22]	Scoping review	54 studies, including surveys and case reports	On-field and ED care of athletes with suspected CSI	NA	NA	NA	NA	Evidence remains moderately circumstantial and anecdotal. Keeping equipment in place has not been found to be detrimental. Adequate data on pediatric and female athletes and breadth of equipment designs not available.

Abbreviations: AT, athletic trainer; CSI, cervical spine injury; ED, emergency department; NA, not applicable; NCAA, National Collegiate Athletic Association; RIQ, Riddell Revolution IQ.

[a] Riddell 360 and Power; Des Plaines, IL.

[b] ION 4D; Schutt Sports, Litchfield, IL.

Supplemental Table 8. Summary of Findings for Question 4: "What Method of Transfer and Spine-Motion Restriction is Associated With the Best Outcomes for Athletes With Suspected CSI, Both in Supine and Prone Position?"

Journal	Year	Authors	Study Design	Study Population	Intervention or Exposure	Comparison Groups	Sport	Outcome	Outcome Measurement Type	Results
Journal of Athletic Training	2013	Conrad et al[48]	Crossover study	5 cadavers; 5 "rescuers" (2 ATs, 1 student, 2 spine surgeons)	Prone log roll technique and equipment removal	Log-roll pull vs log-roll push wearing shoulder pads and helmet vs collar only vs no equipment	American tackle football	Dynamic angulation or translation motion in all 3 anatomic planes	Electromagnetic motion analysis	Log-roll push produced less lateral bending motion than log-roll pull. No other significant differences were noted between methods or equipment conditions across any of the 6 motion measures.
Orthopaedic Journal of Sports Medicine	2017	Etier et al[25]	Crossover study	20 male participants in 4 weight groups; 7 staff (2 ATs, 3 sports med ortho fellows, 2 sports med ortho surgeons)	Immobilization and equipment removal	(1) Rigid spine board vs full-body vacuum splint; (2) helmet and shoulder pads vs no equipment; (3) weight group	American tackle football	Peak planar cervical spine motion, perception of comfort and security	Electromagnetic motion analysis	Small but significant differences in cervical motion were noted between immobilization types under various test conditions. Body weight was associated with motion under a variety of test conditions.
Orthopaedic Journal of Sports Medicine	2015	Prasarn et al[49]	Controlled laboratory study	5 cadavers; unspecified study staff (spine surgeons, residents, ATs)	Spine-board transfer technique	Log roll vs lift and slide vs 8-person lift	American tackle football	Relative angular and linear motion	Electromagnetic motion analysis	8-person lift resulted in less motion in all planes compared with other techniques. Lift and slide was more stable than log roll.
Journal of Athletic Training	2000	Ransone et al[50]	Crossover study	10 male former football players	Immobilization	Helmet and shoulder pads vs helmet, shoulder pads, and cervical vacuum immobilizer	American tackle football	Voluntary cervical spine range of motion	Radiography	Vacuum immobilization significantly decreased range of motion.

Abbreviations: AT, athletic trainer; CSI, cervical spine injury.

Supplemental Table 9. Summary of Findings for Question 5: "What Formal Training in the Emergency Care of an Athlete With an On-Field Suspected CSI Is Required and Recommended?"

Journal	Year	Authors	Study Design	Study Population	Intervention or Exposure	Comparison Groups	Sport	Outcome	Outcome Measurement Type	Results
Athletic Training & Sports Health Care	2015	Lenhardt et al[46]	Randomized nonblinded crossover study	Unspecified models; 31 certified athletic trainers, 1 senior student	Shoulder-pad removal technique	Elevated torso with traditional shoulder pads vs flat torso with traditional shoulder pads vs Riddell RipKord pad removal[a]	American tackle football	Head motion, time to removal, perceived difficulty	Electromagnetic motion capture; modified Borg CR-10 scale	Riddell RipKord removal was faster than other techniques, rated as less difficult. No significant different in head motion across the techniques. Reinforced training improved speed and decreased range of head motion.
Spine	2002	Peris et al[27]	Controlled laboratory study	7 male participants; 4 research staff	NATA protocol for removal of equipment	Before removal vs during elevation vs after helmet removal vs after shoulder pad removal vs no equipment	American tackle football	Angulation C2-C6, disc height at C2-C3, translation at C5-C6, SAC	Digital fluoroscopy	No significant change in disc height, translation, or SAC. No significant motion in angulation.
American Journal of Sports Medicine	2004	Waninger[22]	Scoping review	54 studies, including surveys and case reports	On-field and ED care of athletes with suspected CSI	NA	NA	NA	NA	Evidence remains moderately circumstantial and anecdotal. Keeping equipment in place has not been found to be detrimental. Adequate data on pediatric and female athletes and breadth of equipment designs not available.

Abbreviations: CSI, cervical spine injury; ED, emergency department; NA, not applicable; NATA, National Athletic Trainers' Association.
[a] Riddell RipKord; Des Plaines, IL.

Supplemental Table 10. Summary of Findings for Question 7: "How Many Trained Personnel Does It Take to Remove a Face Mask/Helmet/Shoulder Pads on the Field?"

Journal	Year	Authors	Study Design	Study Population	Intervention or Exposure	Comparison Groups	Sport	Outcome	Outcome Measurement Type	Results
Spine	2009	Horodyski et al[51]	Crossover study	5 cadavers; unknown study staff	Shoulder pad removal technique	Flat-torso technique vs elevated-torso technique	American tackle football	Angular and linear displacement	Electromagnetic motion analysis	Elevated-torso technique involved less C5-C6 motion if instability was present. Similar results were found with intact spines.

Supplemental Table 11. Questions, Conclusions, Recommendations, and Consensus Scores (1–9)

Question	Conclusions	Mean ± SD	Recommendations	Mean ± SD
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.	8.65 ± 0.70	Procedure should be developed to ensure that an injured 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.	7.44 ± 1.17
2a: Are outcomes after CSI likely to be better when face masks are removed prior to transport?	Removal of face masks in American tackle football with proper equipment by skilled personnel can be done with minimal motion of the cervical spine.	8.44 ± 0.7)	Access to airway should be obtained prior to transport in athletes with suspected CSI.	8.59 ± 0.60
			American tackle football face masks should be removed prior to transport in athletes with suspected CSI.	8.17 ± 1.17
			Tools and trained personnel should be available for face-mask removal.	8.22 ± 1.65
2b: Are outcomes after CSI likely to be better when the helmet/shoulder pads are removed prior to transport?	Removal of helmets alone without removal of shoulder pads may result in malalignment of the cervical spine in American tackle football, men's lacrosse, and ice hockey.	8.00 ± 0.87	The highest priority is maintaining cervical alignment.	8.33 ± 1.29
	Removal of helmets and shoulder pads creates small, statistically significant amount of spinal movement in American tackle football, men's lacrosse, and ice hockey.	7.89 ± 1.12	Helmet and shoulder-pad removal should be left to the discretion of trained personnel at the scene.	7.89 ± 1.17
	It is unknown what degree of cervical spine motion during equipment removal is clinically significant.	8.37 ± 0.67	When helmet and shoulder pads are to be removed, they should be removed by trained personnel with competency in equipment removal while minimizing cervical spine motion.	8.33 ± 0.75
	Alignment of the cervical spine is statistically equivalent when the helmet and shoulder pads are on versus when the helmet and shoulder pads have been removed.	7.94 ± 0.80	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.	7.33 ± 2.11
3a: What criteria should be considered when deciding to remove face masks with a suspected CSI?	None		The highest priority is maintenance of circulation, airway, and breathing.	8.79 ± 0.41
			Prior to transport, airway access should be ensured.	7.79 ± 1.67
			Any athlete transported with a suspected CSI should have the face mask removed for airway access.	7.16 ± 1.95
			The condition of the face mask, hardware, available equipment, and training of the available personnel should be considered prior to face-mask removal.	7.68 ± 1.08
			Providers should have more than 1 method for face-mask removal available.	8.11 ± 1.55
3b: What criteria should be considered when deciding to remove helmet/shoulder pads with a suspected CSI?	The highest priority when considering helmet/ shoulder-pad removal is maintaining circulation, airway, and breathing.	8.56 ± 0.60	The highest priority is maintenance of circulation, airway, and breathing.	8.58 ± 0.67
	Athlete weight can be considered when deciding to remove helmet/shoulder pads	7.40 ± 1.16	Trained personnel should remove the helmet and shoulder pads from athletes with compromised circulation, airway, or breathing or decreased level of consciousness.	8.11 ± 1.02
	Make and model of equipment can be considered when deciding to remove the helmet/shoulder pads.	7.40 ± 1.16	Athlete height and weight; make, model, and condition of equipment; and type of immobilization devices available should all be considerations when	7.79 ± 1.06

	The type of immobilization device available and the sport involved can be considered when deciding to remove helmet/shoulder pads.	7.26 ± 1.21	deciding whether to remove the helmet and shoulder pads prior to transport.	
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?	Log-roll–push techniques are superior to log-roll–pull techniques when turning injured athletes who are prone.	7.58 ± 1.04	The highest priority during any transfer technique is maintaining cervical spine alignment.	8.40 ± 0.65
	Lift and slide with adequate personnel (8-person lift) results in less movement of the spine than log roll.	8.05 ± 0.94	The medical professional in charge at the scene must apply clinical judgement to determine the best transfer technique.	8.52 ± 0.59
	Full rigid spine board and full-body vacuum immobilization are equivalent in the degree of immobilization of the cervical spine.	7.58 ± 0.88	When feasible, a lift-and-slide technique (eg, 8-person lift) for supine athletes and log-roll–push technique for prone athletes should be implemented during transfer of athletes with suspected CSI.	7.33 ± 0.99
			In nonathletes, there are data to confirm that a scoop stretcher is an acceptable device to minimize spine motion for immobilization in the supine patient.	7.76 ± 1.19
			The medical team should be proficient with multiple transfer techniques in order to provide the best on-scene care.	8.10 ± 1.34
			The size of the athlete may be a factor in the selection of the appropriate spinal-motion restriction equipment (eg, standard vs oversized long spine board).	7.81 ± 1.47
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 ability to care for a suspected spine-injured athlete.	8.10 ± 1.02	The highest priority is that all personnel on site are adequately trained and have rehearsed the techniques necessary to protect the spine of the spine-injured athlete.	8.38 ± 0.79
			Training should be scenario based and practical, simulate emergency conditions, and encompass all members of the interdisciplinary health care team.	8.52 ± 0.50
			Venue-specific training and rehearsal (including at practice facilities and game sites) should occur at least annually.	8.19 ± 0.66
			Sports medicine teams should conduct a prepractice and pre-event review of emergency action plans (EAPs) including equipment, roles, and communication.	8.14 ± 0.83
			Sports medicine teams should conduct a pre-event “medical time out.”[a]	8.33 ± 1.17
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?	There are no studies that address this question.	7.65 ± 1.82	The highest priority should be maintaining circulation, airway, and breathing while minimizing cervical spine motion with suspected CSI in such a way as to minimize further neurologic impairment.	8.05 ± 0.80
			Sufficient alignment should be achieved to maintain a patent airway.	8.37 ± 0.58
			In an awake, responsive, and cooperative athlete, trained medical personnel should employ clinical judgment and discretion before working with the patient to gently actively or passively attain in-line cervical spine stabilization prior to transport.	7.47 ± 1.09
			Active manipulation of the spine should be avoided if the athlete has impaired consciousness, unless deemed necessary by trained medical personnel to maintain circulation, airway, and breathing.	7.10 ± 1.09
			Cervical spine realignment procedures should be abandoned and the neck stabilized in the current position if there is increased pain, neurologic deterioration, or resistance to movement.	7.25 ± 1.48

7: How many trained personnel does it take to remove a face mask/helmet/shoulder pads on the field?	There are no studies that address this question.	8.28 ± 0.93	Trained medical personnel on site should employ clinical judgment and discretion in determining the number of people necessary to safely remove the face mask based on the type of face mask.	8.05 ± 0.80
			Ideally, there should be 2 people involved in removing the face mask: one to maintain in-line stabilization while the second removes the face mask.	8.10 ± 0.77
	There are no data to make a conclusion about the number of people necessary to remove a helmet.	8.00 ± 0.73	Trained medical personnel on site should employ clinical judgment and discretion in considering equipment design and determining the number of trained personnel necessary to safely remove the helmet/shoulder pads.	7.95 ± 1.00
	There are insufficient data to determine the number of personnel needed to remove shoulder pads.	7.45 ± 0.92	The number of trained personnel recommended to remove helmet/shoulder pads depends upon the technique used, athlete size, and equipment present.	8.25 ± 0.77
			There should be at least 2 trained personnel involved in removing the helmet: one to maintain in-line stabilization while the second removes the helmet.	8.26 ± 0.71
			If using the torso-tilt method, a minimum of 4 trained personnel are needed to remove shoulder pads. The torso-tilt method should not be used with suspected thoracic or lumbar injury.	7.65 ± 1.06
			If using the flat-torso method, a minimum of 2 trained personnel are needed to remove shoulder pads.	7.70 ± 1.05
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?	If a cervical collar has been placed after a suspected CSI, it should stay in place during transport.	8.21 ± 0.83	The highest priority is protecting the spine of the athlete with a suspected CSI.	8.45 ± 1.02
	The athlete-specific literature does not address this question.	7.00 ± 2.10	The decision to transport using spinal precautions should be at the discretion of trained personnel on site and local emergency medical services.	8.16 ± 0.81)
	Based on the nonathlete data, in suspected CSI, spinal motion restriction equipment should be left in place for transport.	7.50 ± 1.75	If a cervical collar has been placed after a suspected CSI, it should stay in place during transport.	8.35 ± 0.65
			If an athlete has a suspected CSI and spinal-motion restriction equipment is in place, that equipment should be kept in place during transport.	7.35 ± 1.93
	Based on the nonathlete data, if a long spine board is used, time on the board should be minimized.	8.20 ± 0.81	If used, time on long board should be minimized.	8.32 ± 0.65
	Spinal-motion restriction equipment may include long spine board, scoop stretcher, Kendrick Extrication Device, vacuum immobilization, cervical collar, straps, head blocks, and tape.	7.78 ± 1.58	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 during the removal process. Spinal-motion restriction must be maintained.	7.90 ± 0.94

Abbreviation: CSI, cervical spine injury; ED, emergency department.

[a] Courson R. National Athletic Trainers' Association official statement on athletic health care provider "time outs" before athletic events. http://www.nata.org/sites/default/files/TimeOut.pdf. Published August 2012.