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Return to Play after Cervical Spine Injuries: A Consensus of Opinion

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Abstract

Study Design Survey.

Objective Sports-related spinal cord injury (SCI) represents a growing proportion of total SCIs but lacks evidence or guidelines to guide clinical decision-making on return to play (RTP). Our objective is to offer the treating physician a consensus analysis of expert opinion regarding RTP that can be incorporated with the unique factors of a case for clinical decision-making.

Methods Ten common clinical scenarios involving neurapraxia and stenosis, atlantoaxial injury, subaxial injury, and general cervical spine injury were presented to 25 spine surgeons from level 1 trauma centers for whom spine trauma is a significant component of their practice. We evaluated responses to questions about patient RTP, level of contact, imaging required for a clinical decision, and time to return for each scenario. The chi-square test was used for statistical analysis, with $p < 0.05$ considered significant.

Results Evaluation of the surgeons' responses to these cases showed significant consensus regarding return to high-contact sports in cases of cervical cord neurapraxia without symptoms or stenosis, surgically repaired herniated disks, and nonoperatively healed C1 ring or C2 hangman's fractures. Greater variability was found in recommendations for patients showing persistent clinical symptomatology.

Conclusion This survey suggests a consensus among surgeons for allowing patients with relatively normal imaging and resolution of symptoms to return to high-contact activities; however, patients with cervical stenosis or clinical symptoms continue to be a challenge for management. This survey may serve as a basis for future clinical trials and consensus guidelines.

Keywords

- ▶ sports
- ▶ clinical decision-making
- ▶ imaging
- ▶ cervical spine
- ▶ return to play
- ▶ spinal cord injury
- ▶ trauma
- ▶ spine

Introduction

An estimated 1,000 cases of spinal cord injury (SCI) related to athletics are treated yearly in the United States, representing 8.9% of total SCI cases,^{1,2} and although much has been written about both surgical and nonsurgical treatment methods, the literature guiding return to function is scant. Transient neurap-

raxia and cervical cord neurapraxia (CCN) have been written about extensively, but still only very low-level medical evidence exists regarding management.^{3–6} The risk of recurrence after return to sports has been debated in the literature, and there is no definitive universally accepted guideline.^{1,7} Various criteria based on numerous retrospective studies for return to play (RTP)

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have been suggested by Torg,⁸ Watkins,⁹ Cantu et al,¹⁰ Bailes et al,¹¹ and Torg and Ramsey-Emrhein⁶; however, the decision regarding RTP is individualized to the specific athlete, the level of function, and the expectations of the athlete.^{7,12–15} Moreover, these return criteria are subjective, difficult to apply clinically, and poorly validated on prospective studies. Completion of a randomized trial regarding RTP may not ever become possible, and instead information on medical decision-making must be found in other sources. A recent meta-analysis of literature evaluating evidence for RTP with various injury patterns concluded that only grade C or D practice recommendations supported by level III evidence at best were available for RTP after SCI.¹⁶ That is, evidence supporting interventions is compiled from limited cohort studies and clinical trials, resulting in clinicians using significant judgment of the current evidence to make patient treatment decisions. In patients with SCI, the data are clear that improved function is dependent upon early initiation of rehabilitation¹⁷; however, in patients with minimal or no deficits, the expectations are greater than in patients with a severe or complete SCI. Once the patient has fully recovered from the injury, decisions must be made to release the patient to a specific level of activity, with return to sports being one of the more demanding levels of function.

Consensus opinion regarding RTP may provide better evidence than individual case reports or small case series regarding opinions about return to sporting activity. Consensus regarding expert opinion can be especially useful in guiding surgical decision-making where other types of evidence are absent or interpretation of available evidence is subjective.^{18,19} This approach has been widely used in the spine literature for interpreting guidelines and assessing interobserver reliability in clinical decision-making.^{20–24} This study was designed to identify the maximum level of sporting activity that a group of experienced spine trauma surgeons would allow patients to participate in after recovery as a guide to making general recommendations, which from a medical perspective is essentially a subjective determination of the likelihood that an individual who returns to sports will suffer an additional significant injury directly related to the original trauma. Whether a patient can function at the preinjury performance level would depend on many factors and cannot be addressed in this article. A treating physician is frequently faced with the decision to release a patient to a given level of contact and currently must make a decision based on his or her own anecdotal experience with little supportive literature. The aim of this study is to offer the treating physician a consensus analysis of expert opinion regarding RTP that can be incorporated with the unique factors of the case for the final individual decision.

Methods

Twenty-five spine surgeons in the Spine Trauma Study Group (STSG) who consider spine trauma to be a significant component of their practice, all from separate level 1 trauma centers, were surveyed.^{20–24} The survey was administered at a national meeting discussing guidelines for cervical neurapraxia. The STSG was founded in 2004 and consists of 50 surgeons

Table 1 Examples of sports as defined by level of contact

Level of contact	Sport
High contact	Tackle football, wrestling, rugby, hockey, gymnastics
Intermediate contact	Basketball, baseball, soccer, skiing
Noncontact	Running, tennis, golf, swimming, cycling
No sports	No release to return to sports of any kind

from 12 countries specifically focused on the study of traumatic spine injuries. Each surgeon was presented 10 common case scenarios involving cervical injuries and asked to identify the level of sports participation they would allow following recovery (► **Tables 1** and **2**). The levels of sports were defined as high-contact, intermediate-contact, noncontact, or no sports, representing the frequency and severity of expected stress on the spine. Cases were categorized into those involving cervical neurapraxia and stenosis, atlantoaxial cervical injury, subaxial cervical injury, and general cervical injury. Participants were also asked how soon after recovery they would allow a return to activity and what would be the minimum imaging studies necessary to make the decision. The surveys were completed simultaneously after an explanation of each scenario, the definition of level of play, the use of time to return as that of return to maximum participation, and the use of imaging tools.

Each brief case scenario (► **Table 3**) represented increased levels of injury and assumed that the patient has fully recovered subjectively and objectively. Full clinical recovery was defined as minimal to no neck pain, return of full or near-full range of motion, and return of normal motor and sensory function. After the recommendations for full recovery were collected, the surgeons were presented with the same scenarios but instructed that the patient had persistent symptoms, such as moderate neck pain, upper extremity paresthesias, or single-level radicular weakness (► **Table 4**). Because this study focused on cervical injury, the levels of contact were stratified by the frequency and severity of head/neck impact (► **Table 1**). The surveyed surgeons were given seven specific time frames within which they would allow the patient to return to the maximum level of play: same game, 1 to 2 days, 1 week, 2 to 4 weeks, 2 to 3 months, 3 to 6 months, or greater than 6 months (► **Table 4**). Finally, the surgeons were asked what imaging studies were the minimum necessary to make the final RTP decision after a history and physical exam—plain radiographs, computed tomography (CT) scanning, and/or magnetic resonance imaging (MRI) scanning.

After the surveys were completed, the data was tabulated for analysis of each case scenario. Chi-square tests were used to analyze nonparametric data. The responses from the orthopedic surgeons were compared with those from the neurosurgeons to determine whether any significant differences in recommendations existed using the Kruskal-Wallis

Table 2 Case scenarios involving various categories of injury and progressing from mild to severe injury presented to surgeons for evaluation

Case	Scenario
Category: cervical neurapraxia and stenosis	
1	A 20-y-old college football player tackles a receiver and experiences sudden-onset bilateral upper extremity paresthesia and arm weakness, which resolves during the on-field evaluation. MRI shows normal canal dimensions.
2	A 20-y-old college football player tackles a receiver and experiences sudden-onset bilateral upper extremity paresthesia and arm weakness, which resolves during the on-field evaluation. MRI shows congenital stenosis, but no cord signal change.
3	A 20-y-old college football player tackles a receiver and experiences sudden-onset bilateral upper extremity paresthesia and arm weakness, which requires a few hours to resolve. MRI shows normal canal dimensions.
4	A 20-y-old college football player tackles a receiver and experiences sudden-onset bilateral upper extremity paresthesia and arm weakness, which requires a few hours to resolve. MRI shows congenital stenosis, but no cord signal change.
Category: atlantoaxial cervical injury with or without fusion	
5	A 20-y-old female diver suffers a minimally displaced upper cervical fracture (C1 ring or hangman's) without neurologic injury that heals with nonoperative treatment.
6	An 18-y-old minor league hockey player is driven into the boards and has the onset of incomplete quadriplegia, which resolves over the next 1 h, and burning in his hands, which resolves over the next 24 h. Plain X-rays show normal alignment but reveal that there is an os odontoideum. He undergoes a posterior C1–C2 fusion, which heals, and his neurologic examination is normal.
Category: subaxial cervical injury with or without fusion	
7	A 21-y-old NCAA Division I football player returning a punt is tackled and suffers a C5 burst fracture but is neurologically intact. It heals with nonoperative treatment in minimal kyphosis.
8	A 17-y-old skier falls and suffers a unilateral facet dislocation at C5–C6 and remains neurologically intact. She undergoes a radiographically successful fusion posteriorly at C5–C6. There is minimal neck pain and a normal neurologic examination.
9	A 19-y-old wrestler is thrown on his head and then develops a persistent radiculopathy. He eventually undergoes an ACDF at C6–C7 with radiographically successful fusion and resolution of the radiculopathy.
10	A 16-y-old rider is thrown from horse, suffering a “teardrop” flexion-compression fracture. She initially has upper extremity paresthesia and mild hand weakness. She undergoes a C5 corpectomy with C4–C6 anterior radiographically successful fusion and her neurologic status returns to normal.

Abbreviations: ACDF, anterior cervical discectomy and fusion; NCAA, National Collegiate Athletic Association; MRI, magnetic resonance imaging.

and Mann-Whitney *U* test. A *p* value <0.05 was considered significant.

Results

Fourteen orthopedic surgeons and 11 neurosurgeons who were members of the former STSG completed the survey. A summary of the level of play recommendations for each scenario with full recovery is shown in ▶ **Table 3**. There were no differences between orthopedic and neurosurgeons (results not shown), so the data was analyzed as one group, which is consistent with a previous finding from this group of fellowship-trained spine surgeons regarding evaluation of cervical dislocation injuries.²⁰ The scenarios in which the surgeons most consistently allowed for return to high-contact sports were the episodes of CCN with early resolution of symptoms and no stenosis on MRI (case 1, 88%, *p* < 0.0001 and case 3, 64%, *p* = 0.03). In the setting of diffuse stenosis and early resolution of CCN, the percentage of surgeons allowing return to high-contact sports dropped to 35% (case 2, *p* = 0.6) and 27% (case 4, *p* = 0.6), with greater heterogeneity of opinions. Cases in which some surgeons favored allowing return to high-contact sports included C1

ring or C2 hangman's fractures that healed nonoperatively (67%, case 5, *p* = 0.005), C5–C6 unilateral facet dislocation presenting neurologically intact with subsequent posterior fusion (56%, case 8, *p* = 0.02), and herniated disks repaired operatively (71%, case 9, *p* = 0.003). The surgeons generally favored a return to a less vigorous level of activity such as intermediate or noncontact sports when the case involved CCN with os odontoideum and C1–C2 fusion (82%, case 6, *p* = 0.04), C5 flexion compression of American Spinal Injury Association grade D with C4–C6 anterior cervical corpectomy and fusion (80%, case 10, *p* = 0.06), and C5 burst fracture treated nonoperatively (52%, case 7, *p* = 0.03). Good consensus was seen for these cases in favoring return to a degree of activity less than high contact. Changes in the clinical scenario to indicate a lack of patient symptom resolution resulted in greater variation and less consensus of recommendations and a lower number of physicians recommending return to high-contact sports (results not shown). With a lack of resolution of symptoms, only case 2 (*p* = 0.03) and case 4 (*p* = 0.02) showed significant consensus in recommending noncontact or no sports activity.

▶ **Table 4** outlines the time frame within which surgeons would allow RTP at the level they recommended. A relative

Table 3 The percentage of surgeons recommending each level of contact assuming resolution of clinical symptoms

Case	Level of contact				p Value ^b
	High ^a	Intermediate ^a	Noncontact ^a	No sports ^a	
Category: cervical neurapraxia and stenosis					
1	88	12	0	0	<0.0001
2	35	26	30	9	0.6
3	64	16	20	0	0.03
4	27	27	37	9	0.6
Category: atlantoaxial cervical injury with or without fusion					
5	67	25	8	0	0.005
6	20	44	38	0	0.04
Category: subaxial cervical injury with or without fusion					
7	44	44	8	4	0.03
8	56	28	16	0	0.02
9	71	25	4	0	0.003
10	16	56	24	4	0.06

^aNo difference between orthopedic surgeons and neurosurgeons recommendations seen, Mann-Whitney *U* test.

^bChi-square test.

consensus in recommending return after 2 to 4 weeks was seen in cases 1 to 4 involving cervical neurapraxia and stenosis. All surgeons recommended waiting 2 to >6 months for cases 5 to 10, involving atlantoaxial, subaxial, or general cervical spine injury patterns. There was no difference in the recommendations of orthopedic surgeons and neurosurgeons for level of activity or time to RTP (results not shown). Recommendations for X-rays (64 to 92%), CTs (20 to 84%), and MRIs (50 to 100%) varied among different cases, indicating a high consensus for obtaining imaging in making recommendations (results not shown). There were also no differences in recommendations between orthopedic surgeons and neuro-

surgeons for imaging prior to making RTP decisions. Most surgeons favored extensive imaging with radiographs, CT, and MRI before allowing RTP.

Discussion

Decisions about safe RTP after cervical injury can be difficult because there are opposing forces to be considered, such as the patient's desires and the medicolegal implications. Other than for CCN, there is almost no literature to determine an appropriate strategy for return to sports after cervical injury. Torg et al reported that cervical stenosis was predictive of

Table 4 The percentage of surgeons choosing each recommended time frame for return to the maximum level of sporting activity

Case	Same game ^a	1–2 d ^a	1 wk ^a	2–4 wk ^a	2–3 mo ^a	3–6 mo ^a	>6 mo ^a
Category: cervical neurapraxia and stenosis							
1	13	22	30	30	0	0	4
2	0	15	45	25	5	0	10
3	0	4	27	36	8	12	8
4	0	0	38	38	5	5	14
Category: atlantoaxial cervical injury with or without fusion							
5	0	0	0	0	17	71	13
6	0	0	0	0	16	40	44
Category: subaxial cervical injury with or without fusion							
7	0	0	0	0	4	48	48
8	0	0	0	0	8	56	36
9	0	0	0	0	8	54	38
10	0	0	0	0	4	48	48

^aNo difference between orthopedic surgeons and neurosurgeons recommendations seen, Mann-Whitney *U* test.

another episode of CCN (53%) but not predictive of catastrophic injury²⁵; however, repeated episodes of neurapraxia and cord contusions were thought to be a relative contraindication for RTP. More recently, Brigham and Capo followed four professional athletes who had cord contusions from presumed hypermobility at C3–C4 or a disk herniation elsewhere in the spine.⁷ Despite the positive findings on radiographic images, the players were completely asymptomatic after stabilization and subsequently returned to professional sports. The authors emphasize close observation, careful assessment, and thorough counseling of the patients. The results of studies of return to professional sports after treatment of cervical injury by Hsu and colleagues supported RTP after treatment of cervical disk herniations, with a greater rate of return for operatively managed cases^{12,26}; however, the authors discussed the unclear consensus in management of patients with herniated disks and concomitant cervical stenosis. Despite evidence to suggest that athletes with spinal stenosis may return to high-contact sports if they are asymptomatic,^{3,6} the current study reveals the prevailing caution regarding RTP when an athlete has lost the space available for the spinal cord.

Morganti et al completed a similar RTP survey based on case scenarios of cervical trauma administered to members of the Cervical Spine Research Society, the Herodicus Sports Medicine Society, and members of the authors' own department.²⁷ An evaluation of 113 responses (32.7% response rate) demonstrated that the consensus on RTP was poor and that most of the differences were based on type of subspecialty interest (i.e., spine or sports) and seniority. Although 49% of respondents reported using guidelines at the time for decision-making, only 1 of 10 survey cases was evaluated as appropriate in this manner. Many respondents did not treat cervical spine fractures on a regular basis. The results of the study presented a question of how recommendations for RTP could be made in the face of limited data. In contrast, our study was directed specifically at spine surgeons at level 1 trauma centers who include trauma as a significant component of their practice. The surgeons surveyed for this study had a thorough understanding of the available literature on transient neurapraxia, including a recent issue of *Spine* that was focused on spine trauma and included an evidence-based review of RTP after transient neurapraxia.²⁸ The conclusions of that review were based on a consensus of members of the STSG, as well as available literature.⁵ Because there is so little literature available on the other scenarios, most of those recommendations were based on expert opinion from clinical experience.

Some important differences can be observed in the RTP recommendations after transient neurapraxia. If a patient had congenital stenosis after an episode of neurapraxia, then experienced trauma spine surgeons were distinctly less willing to allow that patient to return to a high-contact sport. If the neurapraxia was brief, 88% would allow return to high-contact sports if the athlete did not have congenital stenosis whereas only 35% would allow the return if congenital stenosis existed. Interestingly, the duration of neurologic deficit played a factor. If the deficit lasted for a few hours

rather than resolving quickly, only 64% would allow return to high-contact sports even if the patient did not have congenital stenosis and just 27% would allow return to high-contact sports if congenital stenosis existed on MRI. Thus, it appears that duration of neurapraxia, perhaps indicating a more significant injury, was important in the RTP decision, as was the presence of congenital stenosis. Our study did not address the issue of repetitive neurapraxia, which could also influence decision-making just as repeated cerebral concussions do.²⁹

The case scenarios set forth do not cover the entire gamut of potential cervical injuries but they were thought to include a broad representation of the common injury patterns so that some extrapolation to other injury patterns may be made. For example, a single-level posterior fusion for facet fracture without dislocation could be assessed in a similar fashion to a single-level posterior fusion for a unilateral facet dislocation in scenario 6. The only other injury patterns in which a majority of those surveyed would allow return to high-contact sports were in the scenarios that resulted in a stable single-level subaxial fusion, either anterior or posterior, and nondisplaced, healed upper cervical fractures. In the scenarios of a healed posterior C1–C2 fusion (even with normal neurology), those with two-level fusions, and those in which patients had an incomplete SCI (excluding transient neurapraxia), only a small minority of less than 20% would consider return to high-contact sports. Absolute contraindications to high-contact sports have generally included patients with odontoid abnormalities, atlanto-occipital fusion, Klippel-Feil fusions above C3, and acute fracture with instability.¹⁶

Limitations of this study include the reliance on expert opinion for surgical recommendations because of the difficulty of studying these injury patterns in the active athlete. The findings are highly dependent on individual interpretation of data and personal experience; however, in the face of convincing data, consensus opinion can be a source of guidance on patient management as well as starting point for further exploration. Other limitations of the study include an inability to totally account for all mechanisms and types of cervical sport injury in making practice recommendations. Clinicians applying this survey may not find every scenario fits their specific patient, although the principles evaluated in each case may be widely applied.

Although this study will not completely answer the questions about RTP, it establishes a reasonable consensus of expert surgeon opinion with substantial experience to guide the treating physician involved in similar case scenarios. It can also serve as a basis upon which future prospective, multicenter studies can be designed to confirm or disprove current dogma.

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References

- 1 Cantu RC, Li YM, Abdulhamid M, Chin LS. Return to play after cervical spine injury in sports. *Curr Sports Med Rep* 2013;12(1):14–17
- 2 Maroon JC, Bailes JE. Athletes with cervical spine injury. *Spine (Phila Pa 1976)* 1996;21(19):2294–2299
- 3 Bailes JE. Experience with cervical stenosis and temporary paralysis in athletes. *J Neurosurg Spine* 2005;2(1):11–16
- 4 Cantu RV, Cantu RC. Current thinking: return to play and transient quadriplegia. *Curr Sports Med Rep* 2005;4(1):27–32
- 5 Dailey A, Harrop JS, France JC. High-energy contact sports and cervical spine neuropraxia injuries: what are the criteria for return to participation? *Spine (Phila Pa 1976)* 2010;35(21, Suppl):S193–S201
- 6 Torg JS, Ramsey-Emrhein JA. Management guidelines for participation in collision activities with congenital, developmental, or postinjury lesions involving the cervical spine. *Clin J Sport Med* 1997;7(4):273–291
- 7 Brigham CD, Capo J. Cervical spinal cord contusion in professional athletes: a case series with implications for return to play. *Spine (Phila Pa 1976)* 2013;38(4):315–323
- 8 Torg JS. Cervical spine injuries and the return to football. *Sports Health* 2009;1(5):376–383
- 9 Watkins RG. Neck injuries in football players. *Clin Sports Med* 1986;5(2):215–246
- 10 Cantu RC, Bailes JE, Wilberger JE Jr. Guidelines for return to contact or collision sport after a cervical spine injury. *Clin Sports Med* 1998;17(1):137–146
- 11 Bailes JE, Hadley MN, Quigley MR, Sonntag VK, Cerullo LJ. Management of athletic injuries of the cervical spine and spinal cord. *Neurosurgery* 1991;29(4):491–497
- 12 Hsu WK. Outcomes following nonoperative and operative treatment for cervical disc herniations in National Football League athletes. *Spine (Phila Pa 1976)* 2011;36(10):800–805
- 13 Kepler CK, Vaccaro AR. Injuries and abnormalities of the cervical spine and return to play criteria. *Clin Sports Med* 2012;31(3):499–508
- 14 Morganti C. Recommendations for return to sports following cervical spine injuries. *Sports Med* 2003;33(8):563–573
- 15 Paulus S, Kennedy DJ. Return to play considerations for cervical spine injuries in athletes. *Phys Med Rehabil Clin N Am* 2014;25(4):723–733
- 16 Eddy D, Congeni J, Loud K. A review of spine injuries and return to play. *Clin J Sport Med* 2005;15(6):453–458
- 17 Labruyère R, Agarwala A, Curt A. Rehabilitation in spine and spinal cord trauma. *Spine (Phila Pa 1976)* 2010;35(21, Suppl):S259–S262
- 18 Levin A, Wheeler DC. A fine balance: developing clinical practice guidelines in areas where evidence is lacking. *Semin Dial* 2015;28(6):654–656
- 19 Wenger DR. Limitations of evidence-based medicine: the role of experience and expert opinion. *J Pediatr Orthop* 2012;32(Suppl 2):S187–S192
- 20 Arnold PM, Brodke DS, Rampersaud YR, et al; Spine Trauma Study Group. Differences between neurosurgeons and orthopedic surgeons in classifying cervical dislocation injuries and making assessment and treatment decisions: a multicenter reliability study. *Am J Orthop* 2009;38(10):E156–E161
- 21 Fehlings MG, Furlan JC, Massicotte EM, et al; Spine Trauma Study Group. Interobserver and intraobserver reliability of maximum canal compromise and spinal cord compression for evaluation of acute traumatic cervical spinal cord injury. *Spine (Phila Pa 1976)* 2006;31(15):1719–1725
- 22 Schweitzer KM Jr, Vaccaro AR, Lee JY, Grauer JN; Spine Trauma Study Group. Confusion regarding mechanisms of injury in the setting of thoracolumbar spinal trauma: a survey of The Spine Trauma Study Group (STSG). *J Spinal Disord Tech* 2006;19(7):528–530
- 23 Vaccaro AR, Hulbert RJ, Patel AA, et al; Spine Trauma Study Group. The subaxial cervical spine injury classification system: a novel approach to recognize the importance of morphology, neurology, and integrity of the disco-ligamentous complex. *Spine (Phila Pa 1976)* 2007;32(21):2365–2374
- 24 Vaccaro AR, Lim MR, Hurlbert RJ, et al; Spine Trauma Study Group. Surgical decision making for unstable thoracolumbar spine injuries: results of a consensus panel review by the Spine Trauma Study Group. *J Spinal Disord Tech* 2006;19(1):1–10
- 25 Torg JS, Guille JT, Jaffe S. Injuries to the cervical spine in American football players. *J Bone Joint Surg Am* 2002;84-A(1):112–122
- 26 Roberts DW, Roc GJ, Hsu WK. Outcomes of cervical and lumbar disk herniations in Major League Baseball pitchers. *Orthopedics* 2011;34(8):602–609
- 27 Morganti C, Sweeney CA, Albanese SA, Burak C, Hosea T, Connolly PJ. Return to play after cervical spine injury. *Spine (Phila Pa 1976)* 2001;26(10):1131–1136
- 28 Fehlings MG, Wilson JR. Timing of surgical intervention in spinal trauma: what does the evidence indicate? *Spine (Phila Pa 1976)* 2010;35(21, Suppl):S159–S160
- 29 Giza CC, Kutcher JS, Ashwal S, et al. Summary of evidence-based guideline update: evaluation and management of concussion in sports: report of the Guideline Development Subcommittee of the American Academy of Neurology. *Neurology* 2013;80(24):2250–2257