Sleep Health 5 (2019) 72–77

Contents lists available at ScienceDirect

Sleep Health

Journal of the National Sleep Foundation

journal homepage: sleephealthjournal.org

Concussion history influences sleep disturbances, symptoms, and quality of life in collegiate student-athletes

Abby L. Blake, BS, Casey L. McVicar, BS, Mckenzie Retino, BS, Eric E. Hall, PhD *, Caroline J. Ketcham, PhD

Department of Exercise Science, Elon University, Campus Box 2525, Elon, NC 27244

ARTICLE INFO

Article history:
Received 1 August 2017
Received in revised form 22 October 2018
Accepted 27 October 2018

Keywords:
Concussion
Sleep
Sleep disturbances
Symptoms
Quality of life
Mild traumatic brain injury

ABSTRACT

Objectives: Immediately after experiencing a concussion, many will report the presence of a variety of symptoms, which may include disturbances in sleep. It is possible that these symptoms and other resulting quality of life (QOL) disturbances may persist for some time following a concussion. The purpose of this study was to determine if a history of concussions was related to ongoing sleep disturbances, symptoms, and changes in QOL.

Methods: Eighty-two student-athletes (club and varsity) completed an online survey to determine concussion history, sleep disturbances, concussion symptoms, and QOL dysfunctions. Separate analyses of variance were performed to determine if sleep disturbances, symptoms, and QOL dysfunctions were related and if they differed based on concussion history (0, 1-2, 3+).

Results: Those with no concussion history reported fewer sleep disturbances ($P = .028$), symptoms ($P = .029$), symptom severity ($P = .014$), QOL dysfunctions ($P = .003$), and QOL severity ($P = .011$) than those who self-reported having had a previous concussion(s). Additionally, the number of sleep disturbances was found to positively correlate with symptoms ($P < .001$), symptom severity ($P < .001$), QOL dysfunctions ($P = .001$), and severity of QOL dysfunctions ($P = .002$).

Conclusions: The results of the current study demonstrate that concussion history is related to persistent changes in sleep, ongoing symptoms, and QOL dysfunctions and should be considered in concussion management protocols even after return to play and academics has occurred.

Introduction

The current issue of concussions and traumatic brain injuries has been viewed as an increasing public health problem[1] and a silent epidemic worldwide.[2] This is due to the increasing number of concussions that are being reported and the subsequent physical and mental health burdens associated with their occurrence.[3] The term *concussion* is defined as a complex pathophysiological process affecting the brain induced by traumatic biomechanical forces and typically results from a forceful, direct blow to the head that may or may not cause a loss of consciousness.[4] The occurrence of a concussion leads to a complex neurometabolic cascade,[5] with individuals who experience a concussion typically displaying a rapid onset of neurological impairments that gradually resolve over time.[4] Individuals who sustain a concussion may exhibit a variety of physical signs (eg, amnesia), symptoms (eg, somatic, cognitive, and/or emotional), impairments in balance and cognition, changes in behavior, as well as sleep/wake disturbances.[4] These signs and symptoms often subside within 7-10 days of the injury.[6] In some cases, however, recovery may be prolonged for weeks or months.

Many individuals who suffer from a concussion report symptoms that affect sleeping patterns in the form of sleep disturbances and changes in sleep duration.[7–11] Research suggests that 30%-80% of people suffering from concussions experience problems such as insomnia, increased time falling asleep, difficulty remaining asleep, and increased fatigue or feelings of tiredness throughout the day.[12,13] *Sleep disturbances* and *sleep duration* are terms that are often used interchangeably but are typically misinterpreted. According to Mahmood et al,[14] *sleep disturbances* are indications of disruption during sleep, such as sleep length, whereas Ouellet et al[15] use the term to indicate the presence of clinical sleep disorders.

Getting proper sleep during the initial recovery stage may be beneficial and help decrease the likelihood of experiencing prolonged symptoms or developing post-concussion syndrome.[7,8] A current hypothesis is that the restorative effect of sleep may be beneficial in helping restore brain energy patterns that have been dysregulated due to a

* Corresponding author at: 2525 Campus Box, Elon, NC 27244. Tel.: +1 336 278 5880.
E-mail address: ehall@elon.edu. (E.E. Hall).

https://doi.org/10.1016/j.sleh.2018.10.011
2352-7218/

concussion.[7] A concussed brain requires adequate sleep during the recovery process to heal and restore the electrochemical balance.[7,16] Altered sleep patterns and sleep disturbances post-concussion hinder the body's ability to recover and restore cognitive and physical functions, therefore prolonging the recovery phase.[7] Research has shown that adolescents who perceive that their sleep is disrupted during the initial recovery process report a greater number and severity of concussion symptoms, which are correlated with functional and social disability 3 months post-concussion.[17,18] Sleep disturbances in the acute post-concussion recovery period have been shown to predict decrements in quality of life (QOL) such as symptoms of depression, anxiety, and apathy 1 year postinjury.[19] Excessive sleep (hypersomnia) during the initial recovery period may indicate continued and prolonged active recovery from a concussion.[17]

Changes in sleep quality and quantity after a concussion have been related to decreased QOL including diminished engagement in physical activity/sport, academic performance, and social/leisure activities.[20] Changes in sleep patterns that inhibit adequate nonrapid eye movement sleep, which is important for energy conservation and nervous system recuperation,[21] result in decreased physiological processes that may hinder muscular recovery and immune responses.[21] The hindering of muscle recovery and repair often produces excess fatigue and muscle soreness, resulting in decreased athletic performance. Poor sleep quality also induces higher levels of anxiety which may result in decreased athletic and physical performance.[20] Depression-like symptoms resulting from sleep disturbances have a direct effect on the impairment of daily functioning and overall QOL because those experiencing decreased mood or depression-like symptoms are likely to withdraw from and limit social interactions.[22] Although the effects of sleep disturbances on concussion recovery seem to be significant, there is a lack of research regarding concussion-related sleep disturbances, particularly the impacts on QOL

The purpose of this study was to determine the effects of concussion history on sleep, symptoms, and an individual's overall QOL. It was hypothesized that individuals who have suffered from a previous concussion will have a greater number of persistent sleep disturbances, symptoms, and QOL dysfunctions than individuals without a history of concussions. Concussion-related persistent sleep disturbances will also be associated with more symptoms and decreased QOL.

Methods

Participants

A total of 82 collegiate club and varsity student-athletes, not currently recovering from a concussion, from a small, private liberal arts college in the southeastern part of the United States were recruited to participate in the study via e-mail and social media platforms. *Student-athlete* was operationally defined as someone who had participated at either varsity or club level at the university. The goal of selecting this population was to sample from a population that would be more likely to experience a concussion. The participants ranged in age from 18 to 25 years old (average = 20.3 ± 1.5 years). Participants were asked to provide information concerning sport currently playing, level of sport (varsity or club), and self-reported concussion history (0, 1-2, or 3+). Self-reported demographic information for the participants is presented in Table 1. Table 2 provides information about sport participation for the sample. All participants provided written consent which was approved by the university's institutional review board.

Measures

Sleep disturbances

The number of sleep disturbances that they were currently experiencing was determined by the number of items that the participant checked off from the following items which are commonly reported sleep disturbances: difficulty falling asleep, restlessness, sleeping too much, sleeping too little, difficulty staying asleep, and fatigue. The participants were also able to report other sleep disturbances. For this study, the total number of sleep disturbances was added together to determine a sleep disturbances score.

Table 1
Participant demographic information

Variable	No. of participants
Sex	
Male	29
Female	52
Choose not to respond	1
Sport level	
Club	47
Varsity	35
Concussion history	
0	40
1-2	29
3+	13

Concussion symptoms

Concussion symptoms were self-reported using the 16-question Rivermead Post-Concussion Symptom Questionnaire (RPQ)[23] The RPQ evaluates commonly reported concussion symptoms on a 5-point Likert scale (0 = not experienced at all, 1 = no more of a problem/symptom is unchanged; 2 = mild problem; 3 = moderate problem; 4 = severe problem).[23] The participants were asked to report whether or not they currently suffered from any of the symptoms at the time of the survey. Total concussion symptom severity was calculated based on the individual responses to each question of the RPQ. Higher total scores indicated increased post-concussion symptom severity, with a maximum score of 64.[23] This test has high test-retest reliability and is widely used in concussion research.[19]

QOL dysfunctions

Functional and social QOL parameters were determined using an adaptation of the Rivermead Head Injury Follow-Up Questionnaire (RHFUQ), which is a 5-point self-report Likert scale (0 = no difficulty; 1 = mild difficulty; 2 = moderate difficulty; 3 = severe difficulty; 4 = unable to engage in activity).[24] This Likert scale was a slight modification from the original scale in that the original asked participants to rate based upon change prior to injury. This change was made to allow for participants who had not reported a concussion to be able to complete. Participants were asked to report if they were currently having difficulty with any of the 10 aspects of overall QOL, including subjective ratings of work outcomes, relationships, social, domestic, and leisure activities.[24] Total QOL dysfunction was calculated based

Table 2
Sports played by participants

Sport	No. of participants
Baseball	15
Soccer	13
Softball	11
Ultimate Frisbee	6
Track and field/cross-country	6
Rugby	6
Lacrosse	5
Volleyball	4
Football	4
Basketball	4
Field hockey	2
Other sports	6

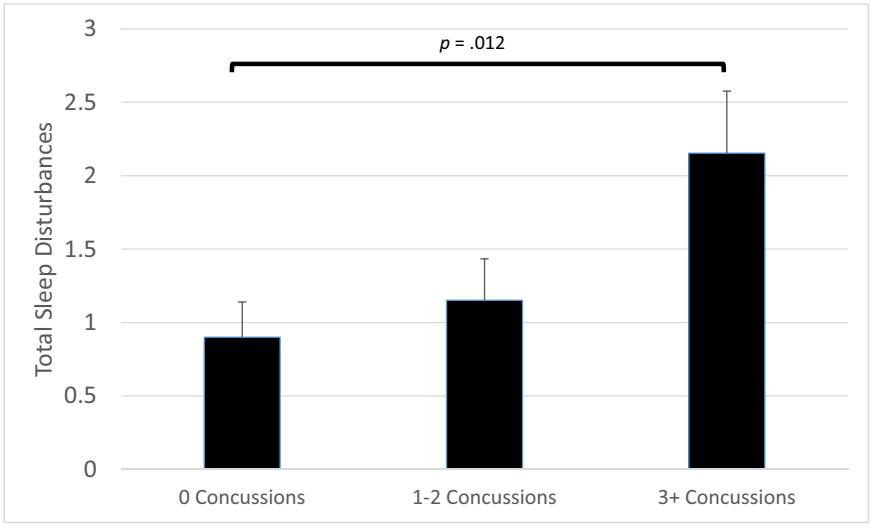

Fig. 1. Total number of sleep disturbances by number of concussions.

on the individual responses to each question of the RHFUQ. Higher total scores indicated decreased quality of life, with a maximum score of 40. This is a reliable measure of functional and social outcomes because the scores correlate with the RPQ.[19]

Procedure

The electronic survey was administered in the Google Forms and distributed to collegiate club and varsity student-athletes via e-mail and social media platforms. Informed consent was provided to participants before completing the survey, and each participant was made aware that they could withdraw from the study at any given time. Participants were asked to report as accurately as possible demographic information including age, sex, sport, concussion history, and medical history as well as questions related to the number of sleep disturbances experienced and the RPQ and RHFUQ questionnaires.

Statistical analysis

All data were analyzed using SPSS 23 (IBM) with an α level of <.05. One-way analyses of variance were conducted to quantify the effects of concussion history (0, 1-2, and 3+ concussions) and sport level (varsity and club) on total number of sleep disturbances, concussion symptoms, severity of symptoms, total number of QOL dysfunctions, and severity of QOL dysfunctions.[1]

Least significant difference post hoc tests were performed on all significant findings to determine which of the groups was responsible for the significant effects. Correlation analyses were completed between total sleep disturbances with the number severity of symptoms, and the number and severity of QOL dysfunctions.

Results

Sleep disturbances

The most common sleep disturbances reported were fatigue (n = 26, 32%), sleeping too little (n = 22, 27%), restlessness (n = 20, 24%), difficulty falling asleep (n = 20, 24%), difficulty staying asleep (n = 11, 13%), and sleeping too much (n = 10, 12%). There were significant differences among the 3 concussion groups for total number of sleep disturbances ($F = 3.73$, $P = .028$). Post hoc analyses revealed that the 0 concussion group had significantly fewer sleep disturbances than those with 3+ concussions ($P = .012$; Fig. 1).

Total concussion symptoms and severity

The most common symptoms reported from the RPQ were headaches (n = 45, 55%), poor concentration (n = 41, 50%), fatigue (n = 40, 49%), forgetfulness/poor memory (n = 39, 48%), feeling frustrated or impatient (n = 36, 44%), and sleep disturbances (n = 33, 40%). There were significant differences among the 3 groups for total concussion symptoms ($F = 3.72$, $P = .029$) and symptom severity ($F = 4.51$, $P = .014$). For total number of symptoms, the 0 concussion group reported fewer symptoms than both the 1-2 concussion group ($P = .020$) and the 3+ concussion group ($P = .046$; Fig. 2). For severity of symptoms, a similar pattern was displayed in that the 0 concussion group reported less severe symptoms than the other 2 groups (1-2 concussions, $P = .012$; 3+ concussions, $P = .024$; Fig. 2).

Total QOL dysfunctions and severity

The most common QOL dysfunctions reported were finding work more tiring (40%), ability to maintain your previous work load or quality of work/school work (38%), the ability to cope or handle family demands (21%), and the ability to maintain conversation with 1 or more individuals (21%). There were significant differences among the 3 groups for total number of QOL dysfunctions ($F = 6.20$, $P = .003$) and QOL dysfunction severity ($F = 4.34$, $P = .016$). For number of QOL dysfunctions, the effect is attributable to the 0 concussion group having fewer dysfunctions than the 1-2 concussions group ($P = .005$) and the 3+ concussions group ($P = .006$; Fig. 3). Similarly, for severity of QOL dysfunctions, the 0 concussion group reported lower severity than the 1-2 concussion group ($P = .034$) and the 3+ concussions group ($P = .011$; Fig. 3).

Correlations between sleep disturbances, symptoms, and QOL

In an effort to determine the relationship between sleep disturbances, symptoms, and QOL dysfunction, correlations were computed. Sleep disturbances were significantly related to total number

[1] Preliminary analyses examined to see if sport level (varsity vs club) influenced any of the dependent variables in the study and found no differences; therefore, these were not included in our analyses.

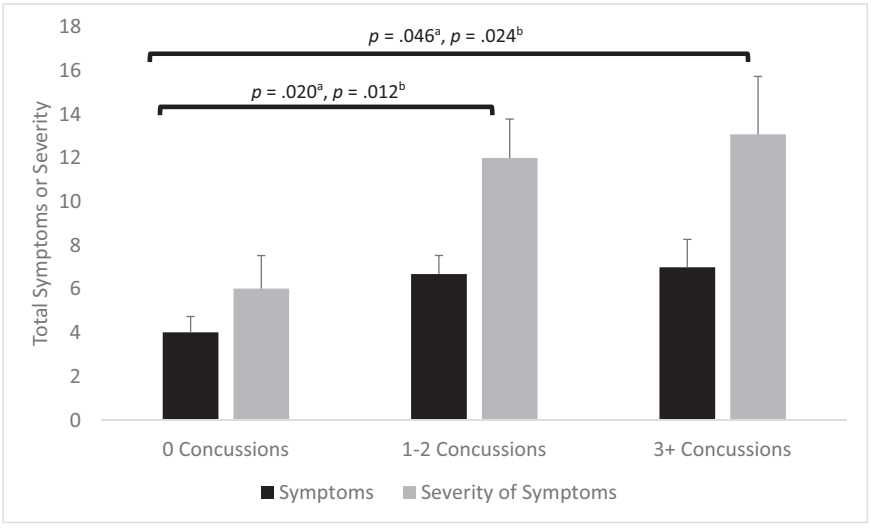

Fig. 2. Concussion symptoms and symptom severity based on number of concussions. [a]Total symptoms, [b]severity of symptoms.

of symptoms ($r = .54$, $P < .001$), severity of symptoms ($r = .48$, $P < .001$), number of QOL dysfunctions ($r = .35$, $P = .001$), and severity of QOL dysfunctions ($r = .34$, $P = .002$).

Discussion

The purpose of this study was to determine the effects of concussion history on sleep disturbances, symptoms, and QOL in collegiate student-athletes. The results from the present study demonstrate that concussion history is related to ongoing sleep disturbances, concussion symptoms, and QOL dysfunctions. Additionally, the number of sleep disturbances was found to correlate with symptoms and QOL dysfunctions. This suggests that experiencing any number of concussions can result in lingering, prolonged symptoms that can affect sleep and QOL.[25]

Despite never experiencing a concussion, the 0 concussion group reported concussion symptoms, sleep disturbances, and QOL dysfunctions. Gaultney[26] found that 27% of the college population was at risk for at least 1 sleeping disorder and explained that altered sleep patterns due to a university setting, class schedules, and lifestyle choices may lead to an increase in concussion-like symptoms in healthy individuals. A recent NCAA survey found that student-athletes had similar rates of insomnia as nonathletes, 3% to 2%, respectively.[27] Similarly, other preexisting conditions such as diagnosis with attention-deficit/hyperactivity disorder or previous treatment for headaches, migraines, and psychiatric conditions (eg, depression) have also been shown to influence in symptom reporting behavior despite not having a concussion.[28] The present study found that although there were only significant differences for total number of sleep disturbances between the 0 concussion group and the 3+ concussion group, the number of symptoms and severity of differences were significantly different between the 0 concussion group and both concussion groups. These findings are consistent with those of Mathias and Alvaro who determined that 50% of people suffered from some form of sleep disturbance after a concussion, which is a much higher prevalence rate than in the general population.[29] They are also consistent with previous work which found that the more concussions one has, the more likely they are to experience insomnia and other sleep disturbances.[30]

There were significant differences between the 0 concussion group and 1-2 concussions as well as the 0 concussion group and 3+ concussions for the number of QOL dysfunctions and severity of QOL

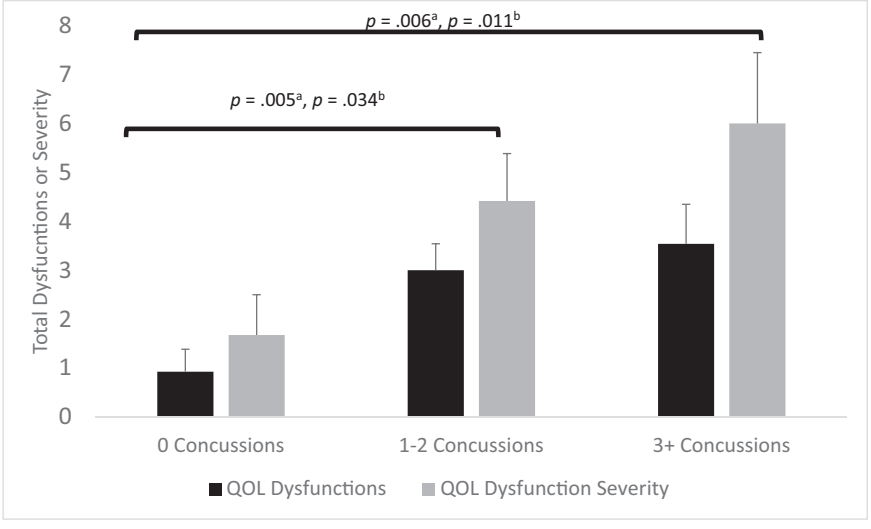

Fig. 3. QOL dysfunctions and severity of dysfunctions based on number of concussions. [a]Total QOL dysfunctions, [b]severity of QOL dysfunction.

dysfunctions. These results suggest that experiencing a concussion can increase the number of QOL dysfunctions experienced, which has been found in previous research.[19,25] Similarly to Chan and Feinstein,[19] the current study also suggests that the presence of concussion-related persistent sleep disturbances negatively impacts multiple QOL components, as those with more sleep disturbances experienced significant declines in QOL.

Understanding concussion-related persistent sleep disturbances is an important topic because they are interrelated with post-concussion symptoms, psychiatric disturbances, and functional disability, which are all factors that contribute to recovery from a concussion and overall QOL.[19] More specifically, proper sleep during initial recovery heals and restores electrochemical balances in the brain, alleviates the severity of symptoms, and improves neurocognitive processes. Individuals who suffer from altered sleep patterns during recovery may also suffer from prolonged or persistent sleep disturbances even after the physical and cognitive symptoms diminish.[21,22]

Altered sleep quality and quantity following a concussion in collegiate student-athletes may also result in decreased overall sport and academic performance.[26] Changes in lifestyle and adapting to a college class and social schedule hinder previous sleep patterns in healthy college students. College students, especially student-athletes, are susceptible to excessive daytime sleepiness as a consequence of sleep deprivation.[26] Prolonged sleep disturbances after a concussion, such as insomnia and difficulty falling asleep, lead to changes in sleep/wake patterns and result in reduced sleep time, which is often associated with lower grades and poorer performance on academic examinations even in healthy individuals.[26] Daytime sleepiness from altered sleep quality and quantity following a concussion may also result in lowered levels of attention and impaired memory and decision making,[31] thus hindering the ability to focus during class and retain information. Research also suggests that adequate, uninterrupted sleep may optimize learning and cognitive functioning because sleep plays an important role in memory consolidation.[32] Indirectly, poor sleep also impedes the learning process by reducing motivation, compromising health, or depressing mood.[26]

Results from the current study may persuade medical professionals to implement objective and subjective sleep assessments to assist current concussion protocols to properly return athletes to physical activity. More research on this topic could result in improved concussion recovery protocols, a better understanding of the complex injury, and improved QOL for the vast number of individuals suffering from concussions.

There are several limitations of the current study. A major limitation of the current research study is that our sample size was modest in size ($N = 82$), and it was difficult to assess if there were differences between sports because of the variability in sports sampled. The current study was cross-sectional in design, and time from concussion varied for each participant, which indicates that the participants may be at different time points following recovery.

Based on the results of this study, future research is warranted in this area. More systematic, longitudinal, and objective measures (ie, activity/sleep trackers) would be valuable to the understanding of concussions on prolonged disturbances in sleep, QOL, and symptom reporting. This would also allow researchers to compare self-reported symptoms to objective measures of sleep and activity.

Conclusions

The results of the current study demonstrate that following recovery and return to normal activity from a concussion, sleep disturbances, symptoms, and QOL dysfunctions often still persist. These data suggest that clinicians may need to follow up with student-athletes more frequently following a concussion to ensure that full recovery has been made. These persistent outcomes could greatly influence effective return-to-play and return-to-learn protocols.

Disclosure

Ms Blake has nothing to disclose.
Ms McVicar has nothing to disclose.
Ms Retino has nothing to disclose.
Dr Hall has nothing to disclose.
Dr Ketcham has nothing to disclose.

References

1. Moser RS. The growing public health concern of sports concussion: the new psychology practice frontier. *Prof Psychol Res Pract*. 2007;38(6):699–704. https://doi.org/10.1037/0735-7028.38.6.699.
2. The Lancet Neurology. Traumatic brain injury: time to end the silence. *Lancet Neurol*. 2010;9(4):331. https://doi.org/10.1016/S1474-4422(10)70069-7.
3. Gordon KE, Kuhle S. 'Reported concussion' time trends within two national health surveys over two decades. *Brain Inj*. 2018;32(7):843–849. https://doi.org/10.1080/02699052.2018.1463105.
4. McCrory P, Meeuwisse W, Dvorak J, et al. Consensus statement on concussion in sport? The 5th international conference on concussion in sport held in Berlin, October 2016. *Br J Sports Med*. April 2017. https://doi.org/10.1136/bjsports-2017-097699 [bjsports-2017-097699].
5. Giza CC, Hovda DA. The new neurometabolic cascade of concussion. *Neurosurgery*. 2014;75(suppl 4):S24–S33. https://doi.org/10.1227/NEU.0000000000000505.
6. Williams RM, Puetz TW, Giza CC, Broglio SP. Concussion recovery time among high school and collegiate athletes: a systematic review and meta-analysis. *Sports Med (Auckl N Z)*. 2015;45(6):893–903. https://doi.org/10.1007/s40279-015-0325-8.
7. Jaffee MS, Winter WC, Jones CC, Ling G. Sleep disturbances in athletic concussion. *Brain Inj*. 2015;29(2):221–227. https://doi.org/10.3109/02699052.2014.983978.
8. Sandsmark DK, Elliott JE, Lim MM. Sleep-wake disturbances after traumatic brain injury: synthesis of human and animal studies. *Sleep*. March 2017. https://doi.org/10.1093/sleep/zsx044.
9. Wickwire EM, Williams SG, Roth T, et al. Sleep, sleep disorders, and mild traumatic brain injury. What we know and what we need to know: findings from a National Working Group. *Neurotherapeutics*. 2016;13(2):403–417. https://doi.org/10.1007/s13311-016-0429-3.
10. Tkachenko N, Singh K, Hasanaj L, Serrano L, Kothare SV. Sleep disorders associated with mild traumatic brain injury using Sport Concussion Assessment Tool 3. *Pediatr Neurol*. 2016;57:46–50.e1. https://doi.org/10.1016/j.pediatrneurol.2015.12.019.
11. Gosselin N, Lassonde M, Petit D, et al. Sleep following sport-related concussions. *Sleep Med*. 2009;10(1):35–46. https://doi.org/10.1016/j.sleep.2007.11.023.
12. Kashluba S, Paniak C, Blake T, Reynolds S, Toller-Lobe G, Nagy J. A longitudinal, controlled study of patient complaints following treated mild traumatic brain injury. *Arch Clin Neuropsychol*. 2004;19(6):805–816. https://doi.org/10.1016/j.acn.2003.09.005.
13. Paniak C, Reynolds S, Phillips K, Toller-Lobe G, Melnyk A, Nagy J. Patient complaints within 1 month of mild traumatic brain injury: a controlled study. *Arch Clin Neuropsychol*. 2002;17(4):319–334.
14. Mahmood O, Rapport LJ, Hanks RA, Fichtenberg NL. Neuropsychological performance and sleep disturbance following traumatic brain injury. *J Head Trauma Rehabil*. 2004;19(5):378–390.
15. Ouellet M-C, Beaulieu-Bonneau S, Morin CM. Insomnia in patients with traumatic brain injury: frequency, characteristics, and risk factors. *J Head Trauma Rehabil*. 2006;21(3):199–212.
16. Sullivan KA, Edmed SL, Allan AC, Karlsson LJE, Smith SS. Characterizing self-reported sleep disturbance after mild traumatic brain injury. *J Neurotrauma*. 2015;32(7):474–486. https://doi.org/10.1089/neu.2013.3284.
17. Kostyun RO, Milewski MD, Hafeez I. Sleep disturbance and neurocognitive function during the recovery from a sport-related concussion in adolescents. *Am J Sports Med*. 2015;43(3):633–640. https://doi.org/10.1177/0363546514560727.
18. Lundin A, de Boussard C, Edman G, Borg J. Symptoms and disability until 3 months after mild TBI. *Brain Inj*. 2006;20(8):799–806. https://doi.org/10.1080/02699050600744327.
19. Chan LG, Feinstein A. Persistent sleep disturbances independently predict poorer functional and social outcomes 1 year after mild traumatic brain injury. *J Head Trauma Rehabil*. 2015;30(6):E67–E75. https://doi.org/10.1097/HTR.0000000000000119.
20. Demirel H. Sleep quality differs between athletes and non-athletes. *Clin Invest Med*. 2016;39(6):27525.
21. Fullagar HHK, Skorski S, Duffield R, Hammes D, Coutts AJ, Meyer T. Sleep and athletic performance: the effects of sleep loss on exercise performance, and physiological and cognitive responses to exercise. *Sports Med (Auckl N Z)*. 2015;45(2):161–186. https://doi.org/10.1007/s40279-014-0260-0.
22. Lin C-H, Yen Y-C, Chen M-C, Chen C-C. Depression and pain impair daily functioning and quality of life in patients with major depressive disorder. *J Affect Disord*. 2014;166:173–178. https://doi.org/10.1016/j.jad.2014.03.039.

23. King NS, Crawford S, Wenden FJ, Moss NE, Wade DT. The Rivermead Post Concussion Symptoms Questionnaire: a measure of symptoms commonly experienced after head injury and its reliability. *J Neurol*. 1995;242(9):587–592.
24. Crawford S, Wenden FJ, Wade DT. The Rivermead Head Injury Follow Up Questionnaire: a study of a new rating scale and other measures to evaluate outcome after head injury. *J Neurol Neurosurg Psychiatry*. 1996;60(5):510–514.
25. Lovell MR, Pardini JE, Welling J, et al. Functional brain abnormalities are related to clinical recovery and time to return-to-play in athletes. *Neurosurgery*. 2007;61(2):352–359. https://doi.org/10.1227/01.NEU.0000279985.94168.7F [discussion 359-360].
26. Gaultney JF. The prevalence of sleep disorders in college students: impact on academic performance. *J Am Coll Health*. 2010;59(2):91–97. https://doi.org/10.1080/07448481.2010.483708.
27. Grandner M. Sleeping Disorders. In: Brown GT, editor. Mind, body and sport: understanding and supporting student-athlete mental wellness. Indianapolis, IN: National Collegiate Athletic Association; 2014. p. 51–53.
28. Cottle JE, Hall EE, Patel K, Barnes KP, Ketcham CJ. Concussion baseline testing: preexisting factors, symptoms, and neurocognitive performance. *J Athl Train*. 2017;52(2):77–81. https://doi.org/10.4085/1062-6050-51.12.21.
29. Mathias JL, Alvaro PK. Prevalence of sleep disturbances, disorders, and problems following traumatic brain injury: a meta-analysis. *Sleep Med*. 2012;13(7):898–905. https://doi.org/10.1016/j.sleep.2012.04.006.
30. Bryan CJ. Repetitive traumatic brain injury (or concussion) increases severity of sleep disturbance among deployed military personnel. *Sleep*. 2013;36(6):941–946. https://doi.org/10.5665/sleep.2730.
31. Kamdar BB, Kaplan KA, Kezirian EJ, Dement WC. The impact of extended sleep on daytime alertness, vigilance, and mood. *Sleep Med*. 2004;5(5):441–448. https://doi.org/10.1016/j.sleep.2004.05.003.
32. Smith C. Sleep states and memory processes in humans: procedural versus declarative memory systems. *Sleep Med Rev*. 2001;5(6):491–506. https://doi.org/10.1053/smrv.2001.0164.