Effect of Sleep-Related Symptoms on Recovery From a Sport-Related Concussion

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Background: Sleep issues are commonly reported in athletes after a sport-related concussion (SRC). Further studies are needed to evaluate screening methods for sleep disturbances and the risk of persisting symptoms after an SRC.

Purpose: To evaluate the association between the Sport Concussion Assessment Tool 5 (SCAT5) symptoms of trouble falling asleep, fatigue (or low energy), and drowsiness and the risk of persisting symptoms ($\geq$28 days to recovery) in adolescent athletes.

Study Design: Cohort study; Level of evidence, 3.

Methods: A total of 519 athletes aged 13 to 18 years reported any sleep-related symptoms with an SRC, scored as none (0), mild (1-2), moderate (3-4), or severe (5-6), at their initial office visit (median, 5.4 days after an SRC). Scores were correlated with the risk of persisting symptoms. A composite "sleep cluster" score (range, 0-18) was calculated by summing the SCAT5 component items for trouble falling asleep, fatigue, and drowsiness.

Results: The results indicated that, compared with athletes who reported that they did not have each symptom, (1) athletes who reported mild, moderate, or severe trouble falling asleep were 3.0, 4.6, and 6.7 times more likely to have persisting symptoms, respectively; (2) athletes reporting mild, moderate, or severe fatigue (or low energy) were 2.6, 4.8, and 7.6 times more likely to have persisting symptoms, respectively; and (3) athletes reporting mild, moderate, or severe drowsiness were 1.9, 4.6, and 6.8 times more likely to have persisting symptoms, respectively ($P < .001$ for all). For every 1-point increase in the sleep cluster score, there was a 1.2-fold increased risk of persisting symptoms and an additional 2.4 days of recovery required ($P < .001$ for both).

Conclusion: Athletes who reported mild, moderate, or severe sleep-related symptoms on the SCAT5 were at a proportionally increased risk of persisting symptoms at the initial office visit.

Keywords: head injuries/concussion; clinical assessment/grading scales; epidemiology; pediatric sports medicine

An estimated 1.1 to 1.9 million sport-related concussions (SRCs) occur each year among children aged $\leq$18 years in the United States, with as many as half going unreported.[5,12,19] An SRC is a major health concern in young athletes, with persons younger than 19 years sustaining the majority of reported SRCs.[1] It has been shown that 1 in 10 high school sport injuries are concussions.[2] There are numerous known sequelae of an SRC, including headaches, vestibular symptoms, mood disturbances, photophobia and phonophobia, concentration issues, and sleep-related symptoms.[9]

While a standard recovery from an SRC among adolescents has been defined as <4 weeks, an increasing amount of literature has shown that a significant proportion of athletes were still symptomatic at $\geq$4 weeks, a condition described as "persisting symptoms after an SRC."[4,7,8,27] A recent study found that 73% of athletes were still symptomatic at 4 weeks after an SRC.[7] Prior concussions, a history of migraines/headaches, female sex, younger age, and preinjury mental health disorders (eg, bipolar disorder and Tourette syndrome) have been associated with persisting symptoms after an SRC.[12,14,16,30] As these factors are predetermined, further research is needed to identify modifiable risk factors for persisting symptoms after an SRC to aid clinicians in promoting recovery.

Postconcussive sleep issues are common and are often overlooked during the initial clinical evaluation. A previous

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study found that up to 70% of concussed athletes reported short- and long-term sleep disturbances during recovery.[13] There are various reported subjective symptoms of sleep disturbances after SRCs, including difficulty falling asleep, restlessness, hypersomnia, insomnia, difficulty staying asleep, and fatigue.[2] Prior research has found that sleep disturbances were often the last symptoms to resolve[10] and may persist up to 6 years after a concussion.[4]

Sleep disturbances after a concussion have been shown to have effects deleterious to recovery.[22] Deficits in sleep secondary to SRCs have been found to compromise physical, neurocognitive, and behavioral function.[26] Sleep issues after an SRC have been associated with increased headache severity and mood disturbances.[24] A history of SRCs was found to be related to persistent sleep disturbances and was shown to negatively affect quality of life.[2]

A wide variety of methods have been used to screen for sleep disturbances after an SRC. Nonstandardized methods were utilized by Bramley et al,[3] who evaluated sleep disturbances after a concussion by asking participants if they had difficulty falling or staying asleep, and Blake et al,[2] who used an online survey to assess sleep disturbances and quality of life after an SRC. Other studies have used standardized methods to evaluate the role of sleep in concussion recovery, including the Pittsburgh Sleep Quality Index,[6,13] Epworth Sleepiness Scale,[31] Insomnia Severity Index,[26] and Post-Concussion Symptom Scale (PCSS).[11,13]

Ludwig et al[20] conducted a systematic review of sleep disturbances in concussion recovery and concluded that the number of articles was limited and that variability in sleep assessments made data synthesis difficult. Future studies were recommended to support the increasing evidence that sleep issues after a concussion may increase the risk of protracted recovery. These authors recommended a standardized, valid sleep assessment to address sleep disturbances after a concussion.

Given the complexities of quantifying and characterizing sleep patterns, a standardized, time-efficient, cost-effective tool that is easy to administer may be beneficial to identify athletes with sleep disturbances and the risk of persisting symptoms after an SRC. The Sport Concussion Assessment Tool 5 (SCAT5) symptom checklist is one of the most widely utilized and researched standardized tools for the assessment of concussions by physicians and other clinicians[32] and includes subjective scoring for trouble falling asleep, drowsiness, and fatigue. A systematic review found that utilizing the SCAT5 was useful for monitoring recovery.[13] Prior evidence has shown that grouping symptoms into clusters, such as sleep-related symptoms, may be beneficial for better understanding SRCs.[18]

To our knowledge, no studies have assessed the prognostic value of sleep-related symptoms and a sleep cluster on the SCAT5 among athletes with an SRC at the initial office visit. The purpose of this study was to determine the association between SCAT5 sleep-related symptoms and the risk of persisting symptoms after an SRC in adolescents.

METHODS

Participants

After receiving ethical approval of the study protocol, we conducted a retrospective cohort study of 519 athletes seen at our institution for the initial evaluation of an SRC between January 2016 and January 2019. Consent was not required by the IRB as this was a retrospective study with data obtained from chart review. The diagnosis of an SRC was made by 1 of 3 sports medicine physicians with extensive experience in concussion management, including K.D. To further standardize our findings, we defined a concussion by utilizing the Consensus Statement on Concussion in Sport from the 5th International Conference on Concussion in Sport: a traumatic brain injury induced by biomechanical forces, caused by a direct blow to the head, face, neck, or elsewhere on the body with an impulsive force transmitted to the head, resulting in a range of clinical signs and symptoms.[21] The physicians used the validated 22-symptom checklist from the SCAT5 in addition to athlete history and physical examinations involving cognitive, musculoskeletal, neurological, and vestibulo-ocular assessments to aid in diagnosing an SRC.

Participants were excluded if they were lost to follow-up or if they had any of the following preexisting conditions: intracranial hemorrhage, psychiatric or mood disorder (excluding anxiety and depression), migraine headache, learning disability (excluding attention-deficit/hyperactivity disorder), or history of substance abuse (alcohol, opioids, and cannabis) based on prior studies.[12,14,15,30] We calculated a priori that a sample size of 221 participants was required to obtain a minimum power of 80% to detect a statistically significant difference between groups.[28]

Procedures

Each participant completed the SCAT5 at the initial office visit. The physicians performed a detailed history and physical examination at the initial office visit and subsequent weekly office visits to determine recovery. Recovery was defined, as previously described by DuPrey et al,[8] as

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Ethical approval for this study was obtained from the Crozer Keystone Health System.

TABLE 1
Scoring of Sleep-Related Symptoms on the SCAT5[a]

	None	Mild		Moderate		Severe	
Trouble falling asleep	0	1	2	3	4	5	6
Fatigue	0	1	2	3	4	5	6
Drowsiness	0	1	2	3	4	5	6

[a]SCAT5, Sport Concussion Assessment Tool 5.

the time interval from the date of injury to the date the physician cleared the athlete to begin the return-to-play (RTP) protocol, which was overseen by the respective school's certified athletic trainer, as outlined in the Consensus Statement on Concussion in Sport.[21] Athletes were required to meet the following criteria to be cleared to start the RTP protocol: symptom free (assessed via history and the SCAT5); normal physical examination findings; returned to school for full days with no academic restrictions; and neurocognitive testing results returned to baseline, if available. The physician was contacted by the certified athletic trainer if the athlete developed any symptoms and/or was not able to complete the RTP protocol. The athlete was then re-evaluated in the office. If athletes chose not to return to sport, they were required to meet all aforementioned criteria to determine clearance.

Persisting symptoms, our primary dichotomous outcome, was defined as ≥28 days to recovery, while standard recovery was defined as <28 days to recovery.[7,8,10,27] All evaluations were performed in clinical examination rooms by 1 of the 3 sports medicine physicians. SCAT5 items related to sleep (trouble sleeping, fatigue, and drowsiness) were categorized as none (score of 0), mild (score of 1 or 2), moderate (score of 3 or 4), or severe (score of 5 or 6) (Table 1). A "sleep cluster" score was calculated by summing the SCAT5 items related to trouble falling asleep, fatigue, and drowsiness into a single continuous item.

Statistical Analysis

Our measure of association for prolonged recovery was the odds ratio calculated using logistic regression models with prolonged recovery (yes/no) as the dependent variable and categorical independent variables characterizing SCAT5 items related to sleep (trouble sleeping, fatigue, and drowsiness) as well as our sleep cluster score. Separate models were run for each individual SCAT5 item related to sleep and our sleep cluster score. We assessed the association between SCAT5 items related to sleep and our sleep cluster score with the number of days to recovery using separate linear regression models. We employed a statistical level of significance of .05. Stata 17 (StataCorp) was used for analyses.

RESULTS

A total of 519 athletes (288 male, 231 female) aged 13 to 18 years, with a mean age of 15.2 ± 1.7 years, were included in our analysis. Athletes presented for the initial office visit a median of 5.4 ± 4.1 days (range, 1-21 days) after an SRC. The mean total number of visits per participant was 5.8 ± 3.7.

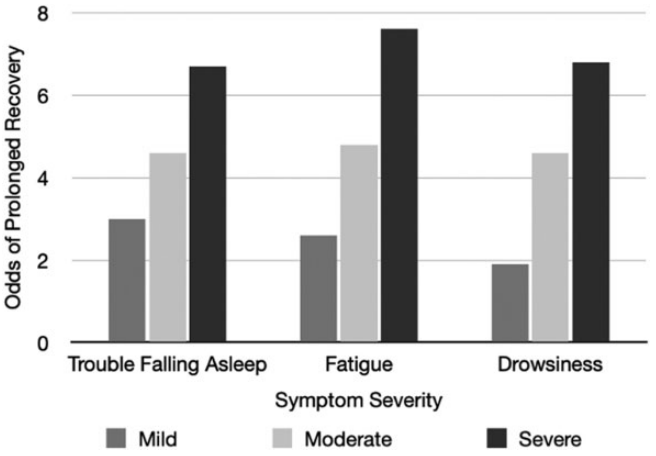

Figure 1. Symptom severity and odds of persisting symptoms after a sport-related concussion (SRC).

Of these athletes, 157 (69 male, 88 female) had persisting symptoms, and 362 (219 male, 143 female) had a standard recovery. Athletes with a standard recovery had a mean time to recovery of 12.6 ± 7.0 days (range, 1-27 days) versus 65.0 ± 67.8 days (range, 28-271 days) for those with persisting symptoms. Athletes with a standard recovery presented earlier for the initial evaluation (5.0 ± 4.5 vs 8.5 ± 10.0 days, respectively), were older (15.5 vs 14.8 years, respectively), and were more commonly male (60.5% vs 43.9%, respectively) ($P < .001$ for all) than were those with persisting symptoms.

Athletes who initially reported mild, moderate, or severe trouble falling asleep were, respectively, 3.0, 4.6, and 6.7 times more likely to have persisting symptoms than were athletes reporting no trouble falling asleep ($P < .001$ for all). Athletes initially reporting mild, moderate, or severe fatigue (or low energy) were, respectively, 2.6, 4.8, and 7.6 times more likely to have persisting symptoms than were athletes reporting no fatigue (or low energy) ($P < .001$ for all). Athletes initially reporting mild, moderate, or severe drowsiness were, respectively, 1.9, 4.6, and 6.8 times more likely to have persisting symptoms than were athletes reporting no drowsiness ($P < .001$ for all) (Figure 1).

In assessing the effect of sleep symptoms on days to recovery, athletes who reported mild, moderate, or severe trouble falling asleep, respectively, took 10.9 ($P = .024$), 21.9 ($P = .002$), and 34.5 ($P < .001$) days longer to recover than did athletes reporting no trouble falling asleep. Athletes who reported mild, moderate, or severe fatigue (or low energy), respectively, took 10.3 ($P = .024$), 11.4 ($P = .028$), and 35.1 ($P < .001$) days longer to recover than did athletes reporting no fatigue (or low energy). Athletes who reported mild, moderate, or severe drowsiness, respectively, took 10.2 ($P = .028$), 16.5 ($P = .002$), and 25.7 ($P = .003$) days longer to recover than did athletes reporting no drowsiness (Figure 2).

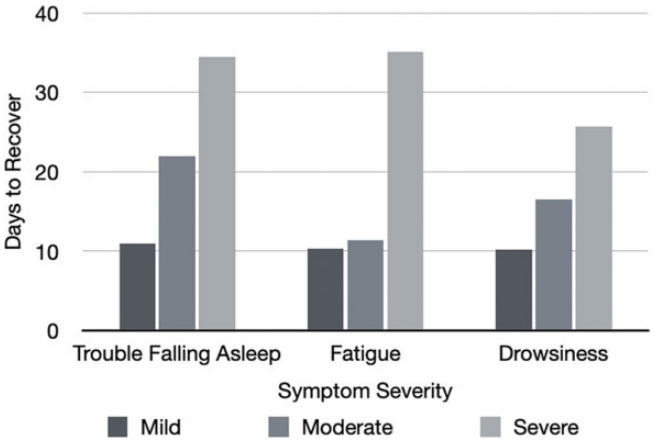

Figure 2. Symptom severity and days to recovery.

For every 1-point increase in the SCAT5 symptom score reported for trouble falling asleep, fatigue (or low energy), and drowsiness, there was a 1.5-fold increased risk of persisting symptoms for each category and an additional 6.2, 4.8, and 4.9 days, respectively, required to recover ($P < .001$ for all). For every 1-point increase in the sleep cluster score, there was a 1.2-fold increased risk of persisting symptoms and an additional 2.4 days required to recover ($P < .001$ for both).

DISCUSSION

Our study showed that athletes who reported sleep-related symptoms on the SCAT5 at the initial office visit were at a statistically significant increased risk of persisting symptoms after an SRC. The analysis illustrated that reporting increased symptom severity was proportionally correlated with recovery duration for each symptom assessed (trouble falling asleep, fatigue, and drowsiness) and when combined as a cluster of sleep-related symptoms. To our knowledge, our study is the first to show that reporting sleep-related symptoms on the SCAT5 independently and when combined as a cluster of sleep-related symptoms was associated with persisting symptoms at the initial office visit.

The correlation between sleep disturbances and persisting symptoms is likely multifactorial. Prior research has shown a complex pathophysiological process in humans after a concussion via increased levels of proinflammatory cytokines and altered levels of neurotransmitters in the hypothalamus, midbrain, and basal forebrain, which may lead to increased sleep fragmentation and decreased sleep efficacy.[29] Whether sleep disturbances are caused by the underlying pathophysiological changes from the concussion or the resulting sleep impairment contributes to persisting symptoms is unknown.

Our study showed that the severity of sleep-related symptoms reported on the SCAT5 was proportionally correlated with increased recovery time. Hoffman et al[13] found that athletes with a shorter sleep duration after a concussion reported significantly higher symptom severity scores and impaired reaction time. Prior research has shown that athletes reporting more severe initial symptoms were at an increased risk for slower recovery.[21] It is possible that other symptoms reported on the SCAT5, such as headache, dizziness, and difficulty concentrating, may be better markers for predicting persisting symptoms; however, further research is needed to assess these non–sleep-related variables and how they may interact with sleep.

Our findings were consistent with those in the current literature, utilizing other methods, showing that sleep is closely related to concussion recovery. Prior research has utilized the Pittsburgh Sleep Quality Index, a 19-item questionnaire requiring 5 to 10 minutes to complete, to show that athletes reporting poor sleep quality took an additional 2 weeks to recover compared to those reporting good sleep quality.[6] Theadom et al[31] used the Epworth Sleepiness Scale, a questionnaire assessing daytime sleepiness, to show that the rate of insomnia after a concussion was >3 times higher than the rate within the general population. Raikes and Schaefer[26] used the Insomnia Severity Index, a validated 7-question survey, to show that daytime sleepiness and insomnia were associated with an increased risk of SRCs. Such scales are more comprehensive than is the SCAT5 for sleep-related symptoms but require up to 10 minutes of additional time to administer and do not assess non–sleep-related concussion symptoms that may be useful in monitoring recovery.

Numerous studies have utilized the PCSS, which is similar to the SCAT5. Murdaugh et al[23] used the PCSS included in Immediate Post-Concussion Assessment and Cognitive Testing to show that sleep disturbances and low sleep quality were correlated with increased neuropsychological and cognitive symptoms specific to a prolonged recovery after an SRC. Kostyun et al[17] found that athletes who reported sleeping less than normal, sleeping more than normal, or having trouble falling asleep on the PCSS had an increased number of concussion symptoms during recovery and demonstrated worse composite scores on Immediate Post-Concussion Assessment and Cognitive Testing compared with athletes who reported no sleep-related issues. Oyegbile et al[24] assessed sleep-related symptoms on the PCSS to show that a history of repeated concussions was associated with a longer concussion duration and increased sleep disturbances. While the PCSS includes an evaluation of trouble falling asleep, drowsiness, fatigue, sleeping more than usual, and sleeping less than usual, we chose the SCAT5, as the most recent Consensus Statement on Concussion in Sport described the SCAT5 as "the most well-established and rigorously developed instrument available for sideline assessment" with utility in tracking recovery.[21]

Prior research has shown that distinct subtypes of an SRC exist in which specific impairments and symptoms cluster together, including sleep-related symptoms.[18] Our study showed that when sleep-related symptoms were combined as a sleep cluster, increased severity correlated with a statistically significant risk of increased recovery time. Other studies have utilized symptom clusters to evaluate the role of sleep in concussion recovery. Guty and Arnett[11] evaluated sleep, physical, cognitive, affective, and headache symptom clusters in collegiate athletes with SRCs to show that reporting any degree of sleep-related symptoms

correlated with memory impairments. Paniccia et al[25] found that autonomic regulation was compromised and correlated with the degree of symptom reporting in athletes after an SRC in all symptom clusters evaluated: fatigue (including drowsiness), physical, cognitive, and emotional. A systematic literature review and meta-cluster analysis of the subtypes of an SRC found that the sleep-emotional cluster (trouble falling asleep, sleeping less, sleeping more, feeling more emotional, feeling slowed down, sadness, nervousness, and irritability) was associated with a prolonged recovery, lower sleep quality, balance deficits, and greater total symptom severity scores.[18] While the review combined sleep and emotional symptoms, further research is needed to investigate sleep clusters alone and recovery from an SRC.

Strengths and Limitations

Our study utilized a practical, cost-effective, and simple method for screening athletes aged 13 to 18 years for sleep disturbances and the risk of a prolonged recovery after an SRC at the initial office visit, assessing separate sleep-related symptoms as well as the sleep cluster on the SCAT5. The SCAT5 can be quickly completed by the patient before or during the initial office visit. The provider can then review the results to determine the presence and severity of sleep-related issues to easily identify athletes at an increased risk of sleep issues and prolonged recovery. After identifying these athletes, the provider could potentially better direct management to address sleep-related issues.

This study had several limitations. First, by definition, self-reported symptom scoring is subjective. Thus, clinicians must rely on the honesty and reliability of athletes completing the checklist. Second is the potential for observer bias. Physicians performing the concussion evaluations were not blinded to history and other physical examination components that may have affected clearance determination. However, physicians were blinded to the variables being evaluated in this retrospective study including recovery time. Third, treatment variability exists among providers. To standardize our methods, we used accepted diagnostic criteria and consensus definitions. Furthermore, the physicians in this study underwent equivalent training at the same institution to manage SRCs and practice in a small group setting, thus minimizing the variability in treatment options provided. In addition, confounding variables such as preexisting sleep disorders may contribute to sleep-related symptoms and symptom severity after a concussion.[13] The physicians in our study specifically discussed SCAT5 symptoms reported with each athlete to differentiate these from preexisting conditions to minimize any potential delayed initiation of the RTP protocol. Furthermore, research has shown that the SCAT5 begins to lose utility at 3 to 5 days after an injury in differentiating concussed from nonconcussed athletes. In our study, the median time to the initial office evaluation after a concussion was 5.4 days; however, research has shown that the symptom checklist within the SCAT5 continues to demonstrate clinical utility in tracking recovery.[21] As the potential for variability exists between physical examinations, the physicians used the same physical examination template and techniques for the initial evaluation including the following: neurological examination including cranial nerve testing, finger-to-nose testing, near point of convergence, Balance Error Scoring System on a solid surface, and cognitive assessment including immediate and remote 3-word recall. Lastly, sleep disturbances are often multifactorial, and potential confounding variables exist when evaluating the role of sleep and sleep-related symptom clusters in SRCs, including preexisting sleep disturbances. Our findings were consistent with prior research showing that female sex, a longer time until the initial evaluation, and younger age were associated with a prolonged recovery after an SRC.[16,21]

Future Directions

The utility of the SCAT5 to assess sleep-related issues in an office setting cannot be understated and should support further research in this field. In athletes who report fatigue, drowsiness, and trouble falling asleep, further questioning during an examination may be beneficial. Discussing the importance of sleep in concussion recovery, sleep hygiene, meditation, supplements such as melatonin, and over-the-counter drugs, or in more severe cases, prescription medication, may be helpful treatment options. Prior research has shown that cognitive behavioral therapy, bright light therapy, aerobic exercise, and acupuncture have improved sleep-wake disturbances in patients after a traumatic brain injury.[29] Bramley et al[3] found that melatonin supplementation improved sleep issues in 67% of patients aged 13 to 18 years with an SRC. Additional studies are needed to examine the efficacy of treatment options for athletes with sleep-related symptoms. Lastly, further studies should be conducted to confirm the initial findings of the present study and evaluate the role of preexisting sleep conditions and sleep clusters in recovery from an SRC.

CONCLUSION

The study findings indicated that sleep-related symptoms on the SCAT5 predicted persisting symptoms in athletes aged 13 to 18 years at the initial office visit. Clinicians should consider utilizing this screening tool to identify athletes at risk of a prolonged recovery.

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