A practical guide to evaluating sleep disturbance in concussion patients

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Abstract

Purpose of review: To provide an introduction and review of sleep metrics appropriate for use with an outpatient concussed population. **Recent findings:** Although sleep issues are frequently identified in concussion, sleep disturbance is rarely assessed in outpatient settings. Given that sleep disturbance may be indicative of, or contribute to, delayed neurocognitive recovery, measurement tools for sleep, rest, and activity behavior may be of both practical and research utility. **Summary:** Because sleep disturbance symptoms may vary between or within an individual throughout the course of recovery, it is recommended that sleep be measured at regular intervals over the entirety of recovery. Included is a discussion on how to select appropriate measures based on patient symptomology in addition to common practical concerns. Additional clinical considerations, a review of traditional pencil and paper methods of continuous sleep behavior monitoring, as well as technologies for measuring sleep and activity behavior are also included. *Neurol Clin Pract* 2016;6:129-137

A 43-year-old woman who had a concussion as the result of a motor vehicle accident 4 weeks previously complains of varied sleep disturbances. Although she reports initial hypersomnia immediately after her injury, she states that in the subsequent weeks her symptoms are more indicative of insomnia (e.g., waking up in the middle of the night and trouble falling asleep) and daytime sleepiness (feeling sleepy at work and falling asleep in front of the television). She asks if this pattern of sleep disturbance is typical following concussion.

Sleep disturbance postconcussion

An estimated 30%–70% of post-traumatic brain injury (TBI) patients report difficulty sleeping in the first few weeks postinjury.¹ Hypersomnia is likely to be present in 25% of TBI patients within the first few days after injury.² Following the acute phase of injury, insomnia symptoms are reported in 30% of people³ and circadian rhythm shifts can also present in approximately 36% of those in the postacute phase.⁴ In addition, 43%–73% of people report symptoms of fatigue.⁵

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Although sleep disturbance is documented among all levels of TBI severity, this article aims to focus on sleep disturbances following concussion. The nomenclature surrounding mild brain injury has been inconsistent and reflects the division between the fields of sports and rehabilitation medicine in mild TBI (mTBI) research. Although concussion falls in the spectrum of mild brain injury and the terms concussion and mTBI are often used interchangeably,⁶ we refer to the popular consensus definition of sport concussion for the purpose of this article⁷ due to its wide acceptance among those involved with rehabilitation and sports medicine practice.

The pattern and time frame of sleep disturbance may vary substantially among patients with concussion. For example, many neurologists may receive a report of excessive sleepiness within the first week after injury, followed by sleeplessness or difficulty falling asleep in the subsequent weeks.

People with concussions often report that they are excessively sleepy in the first week following injury and may report taking daytime naps. However, 2 to 3 weeks after their injury, they may report difficulty falling asleep or early morning awakenings, which in turn may be fueling daytime fatigue. It is important that health providers be able to evaluate both nighttime and daytime sleep behavior as these sleep patterns may be ultimately linked to a 24-hour circadian shift or, alternatively, nighttime sleeping difficulties may be the root of daytime sleepiness.

Despite their pervasiveness and consequences, changes in sleep behavior are not often addressed in the course of concussion recovery. This is important as complaints of insomnia, in particular, have been reported to persist from a few weeks to 2 to 3 years after the initial injury.⁵ Notably, it also appears that people with concussion report greater incidence of sleep disturbance vs those with moderate to severe brain injury.⁵ This may be because those with concussion return to work and daily schedules sooner despite not being completely recovered, and thus sleep problems persist longer in this population.⁵

Because neurologists frequently encounter postconcussion patients, it is especially important to develop an awareness of sleep disturbances associated with concussion and to also be familiar with tools to make appropriate assessments. This article provides a general review and guide to selecting sleep-monitoring measures (both low and high technological options) and discusses strategies for behavioral sleep assessment in clinical settings.

Current assessment of sleep, rest, and activity

Following concussion, specific assessment of sleep behavior is often limited. One or two questions may be asked as part of a larger symptom checklist such as the ImPACT.^{8,9} Many sleep assessment questionnaires are administered one time at patient intake and occasionally repeated at patient discharge. Moreover, these assessments are usually state-based, and are only designed to capture a snapshot of sleep behavior in an abbreviated time span. For example, the ImPACT symptom questionnaire only asks whether one has felt excessively sleepy or has had difficulty falling asleep within the past 7 days. State-based, global measures may provide a gross estimate of sleep behavior within persons with concussion, but may be insufficient in a concussed population whose state may be changing with recovery. Moreover, what may present as a sleep problem may actually be indicative of disruption of the 24-hour circadian system that affects day and nighttime sleepiness. As such, individual monitoring by neurologists of both nighttime sleep and daytime activity/rest is necessary to gain a complete picture of recovery.

Which measures to use?

In conducting a sleep evaluation, neurologists might ask themselves the following questions: (1) What types of sleep issues is the individual reporting? (2) How long has he or she been reporting sleep issues? (3) Have the reported symptoms changed over the course of treatment? (4) Would it be useful or feasible to monitor this individual's sleep habits over time? For example, if a person responds to "I'm sleeping more than usual" on the ImPACT, a follow-up with assessment of daytime sleepiness as well as nighttime patterns would be indicated. Alternatively, if a person indicates that he or she has difficulty falling asleep at night but takes many naps throughout the day, a clinician may choose to implement a sleep and rest diary or daytime activity monitoring to measure daytime vs nighttime sleep behavior.

In addition to a patient's reported sleep symptoms, neurologists may also take practical considerations into account when choosing how to monitor sleep behavior: (1) Will you see the patient once or will he or she return for follow-up appointments? (2) How much time will you have to assess sleep during each individual appointment? (3) How much time will you or an additional clinician have to score or interpret sleep data? (4) Are free or low-cost measures preferred or are more expensive, high-tech options available to you or the patient?

In the event that this patient is seen on a one-time basis, the neurologist may decide to give a few short, state-based sleep questionnaires to assess both insomnia and daytime sleepiness. However, if patient is seen on several occasions over the coming weeks, the neurologist may choose to administer both state-based questionnaires and continuous sleep measures. This would include administering self-report questionnaires at each appointment, based on the patient's reported symptoms. In regards to continuous sleep monitoring, the clinician would present and explain the use of a daily sleep diary that a patient would complete at home, in between appointments, and would bring back on subsequent appointment. Sleep diaries, such as the popular Consensus Sleep Diary, provide data related to nighttime sleep behavior and daytime napping, but can also track other health behaviors such as daily caffeine and alcohol use.¹⁰ Alternatively, or in addition to sleep diaries, if a patient owns an actigraphy device such as a FitBit, Jawbone Up bracelet, or Garmin Vivofit, or the facility has access to similar devices, the neurologist may choose to incorporate high-tech options into patient care and continuous sleep and activity monitoring. An added benefit of using objective and automatic sleep/activity monitoring over self-report diaries is the lessened cognitive demand on patients in regards to memory, language, planning, and organizational abilities. Especially in instances when patients are still highly symptomatic, reducing cognitive burden may be of primary concern.

In light of the need for a more complete assessment of sleep behavior in concussed populations, we present a summary of commonly used sleep questionnaires and technologies that can be used with concussion patients (table). These measures were specifically selected due to their user-friendliness, availability, and psychometric soundness, as well as their adaptability to be used with a brain-injured population. Assessment may aim to estimate sleep behavior in an abbreviated time span or may aim to measure sleep behavior on a more long-term basis. The sleep measures discussed will provide both useful and flexible options in regards to cost, availability, and administration time for clinicians aiming to more carefully and systematically assess sleep in concussion patients. We chose to only include measures that are most relevant to reported postconcussion sleep issues (insomnia, hypersomnia, circadian dysrhythmia, and daytime sleepiness). There are a number of additional popular sleep measures, such as the Karolinska sleepiness scale,¹¹ Sleep Timing Questionnaire,¹² and additional fatigue measures also available to clinicians.

Sleep and activity measures

In this section, the measures presented in the table are described specifically.

ImPACT symptom checklist The symptom checklist in the widely used ImPACT[®] for concussion addresses a number of common post-TBI symptoms, including sleep and daytime

Table 1 Summary chart of common sleep measures

	Description	Symptoms addressed	Scoring	Advantages	Disadvantages	Administration length	Administrator	Ease of administration	Level of symptom monitoring	Level of cognitive demand	Cost
Actigraphy	Small, non-invasive units usually worn on a patient's wrist aimed to measure gross motor activity	Insomnia, Hypersomnia, Circadian Rhythm Disorders	Variable	Provides continuous monitoring of sleep and motor activity. Notes other common post-TBI sleep problems such as circadian rhythm shifts that other sleep measures often fail to capture	Questionable reliability and validity in neurological populations. Traditional actigraphs can be expensive, though newer units are often available at competitive price points	Variable	Self-administered	Easy	Continuous	Low	\$99 and up
Epworth Sleepiness Scale (ESS)	Easy and simple self-administered pencil-and-paper questionnaire aimed to measure general daytime sleepiness	Daytime sleepiness	Scores >10 indicate medical advice should be sought	Provides a general sense of reported daytime sleepiness and dysfunction. Appropriate for all ranges of TBI	State-based questionnaire and is not appropriate for continuous monitoring of patient sleep behavior	5 min	Self-administered	Easy	Single or Interval	Low	Free
ImPACT symptom checklist	22-item computerized global concussion symptom checklist included in larger ImPACT battery	Insomnia, Hypersomnia, Drowsiness	Scores >7 can be abnormal for men Scores >10 can be abnormal for women	Quick and easy to assess whether there are difficulties trouble falling asleep, sleeping more than usual, less than usual and/or daytime drowsiness	State-based questionnaire that does not allow for continuous monitoring of symptoms and relies heavily on only 4 sleep-related questions	25 min	Self-administered or clinician	Easy	Single or interval	Low	Variable depending on package pricing
Insomnia Severity Index	Quick and easy 7-item self-administered pencil and paper questionnaire aimed to measure insomnia symptoms	Insomnia	0-7 = no clinical insomnia; 8-14 = sub-threshold insomnia; 15-21 = moderate insomnia; 22-28 = severe insomnia	Provides cursory overview of insomnia symptoms. Appropriate for all levels of TBI	Only addresses insomnia symptoms. Insomnia symptoms often comorbid with other health and psychiatric disorders	5 min	Self-administered	Easy	Single or interval	Low	Free

Continued

Table 1 Continued

	Description	Symptoms addressed	Scoring	Advantages	Disadvantages	Administration length	Administrator	Ease of administration	Level of symptom monitoring	Level of cognitive demand	Cost
Pittsburgh Sleep Quality Index	18-item pencil-and-paper self-report questionnaire that yields an overall global score in addition to 7 component scores including: subjective sleep quality, sleep latency, sleep duration, sleep efficiency, sleep disturbances, use of sleep medication and daytime dysfunction	Insomnia	A global score of >5 is indicative of disturbed sleep	It is easily accessible from the authors' website, simple to score and is no cost to the administrator. The PSQI is one of the most widely-used sleep measures and has been shown to be a valid measure for assessing sleep disturbance in a TBI population	Although the PSQI may be sensitive to insomnia symptoms and sleep quality it may be less sensitive to symptoms of circadian disorders or hypersomnia	10 min	Self-administered	Easy	Single or interval	Low	Free
Polysomnography	High-tech clinical option that records sleep in an overnight laboratory setting. PSG's record brain waves (EEG), eye movements (EOG), muscle movement (EMG) and heart rhythm data (EKG)	Insomnia, hypersomnia, circadian rhythm disorders, obstructive, sleep apnea	Variable	Preferred option if a patient is experiencing additional sleep problems (e.g., sleep apnea or excessive snoring). Also provides a unique analysis of sleep architecture (e.g., amount of time spent in various sleep stages)	PSG findings are likely contingent on the length of time between the study and the original TBI and only provide insight into one night of sleep. Also a considerable investment of time and economic resources	Requires overnight stay in laboratory setting	PSG technician	Difficult	Single	Low	Variable
Sleep Diaries	Considered the "gold standard" of sleep research, in which patients complete sleep diaries upon waking each morning, noting a number of variables such as the time they went to bed, fell asleep and any nighttime awakenings	Insomnia, hypersomnia, circadian rhythm disorders	Sleep efficiency <85% can be indicative of insomnia symptoms; sleep onset latency >30 min can be indicative of insomnia symptoms; wake after sleep onset >30 min can be indicative of insomnia symptoms	Reliable and valid measure of sleep parameters and are available at no cost and are easily downloadable from online clinical resource centers	May be difficult for patients with lingering cognitive difficulties or more severe forms of TBI to complete on a daily basis. Rely heavily on memory and concentration and may be too mentally taxing for those who are heavily symptomatic	Variable	Self-administered	Moderate	Single, interval or continuous (recommended 14-d continuous monitoring)	Moderate; memory, organizational and motor demands	Free

Abbreviation: PSG = polysomnography; PSQI = Pittsburgh Sleep Quality Index; TBI = traumatic brain injury.

fatigue. The symptom checklist assesses the following sleep behaviors: (1) drowsiness, (2) trouble falling asleep, (3) sleeping more than usual, and (4) sleeping less than usual. The ImPACT Symptom Checklist and neurocognitive subtests have been shown to be both reliable and valid.¹³

Pittsburgh Sleep Quality Index (PSQI) The PSQI¹⁴ is an 18-item pencil-and-paper self-report questionnaire that assesses a variety of sleep-related behaviors including time to fall asleep, estimated total amount of sleep last night, sleep disturbances, reported sleep quality, and use of sleep medication. It yields an overall global score ranging from 0 to 21 as well as 7 component scores that assess the following domains: subjective sleep quality, sleep latency, sleep duration, sleep efficiency, sleep disturbances, use of sleep medication, and daytime dysfunction. It has consistently been shown to be both a reliable ($\alpha = 0.83$) and valid measure of sleep disturbance.¹⁴

Epworth Sleepiness Scale (ESS) The ESS¹⁵ is a quick, simple, reliable ($\alpha = 0.82$), and attainable self-administered questionnaire aimed to measure general daytime sleepiness. The 8-item questionnaire asks how likely a person is to fall asleep during daily activities such as driving and watching television.

Polysomnography (PSG) PSG is a more expensive, high-tech clinical option in which a patient's sleep is recorded in an overnight laboratory setting. PSGs record brain waves (EEG), eye movements (electro-oculography), muscle movement (EMG), and heart rhythm (ECG) data. A novel alternative of at-home PSG monitoring, also known as ambulatory PSG, has also recently become available to many sleep specialist clinics. Although PSG can inform clinicians of a patient's sleep architecture or the presence of sleep apnea symptoms, typical PSG patterns of post-TBI patients have been conflictive. While some reports indicate greater slow-wave sleep post-TBI, other studies report no significant changes in sleep architecture.

Actigraphy Actigraphs are small, noninvasive units usually worn on a patient's wrist aimed to measure gross motor activity. Although traditional actigraphs can be expensive and are mainly used for research purposes, newer devices such as the FitBit can offer activity and rest monitoring at a competitive price point. Actigraph technology varies by device model; while some devices use pedometer technology (usually worn around the waist), accelerometers are usually worn on the wrist or ankle to track movement.

Sleep diaries Sleep diaries are considered the gold standard of sleep research and offer a simple, low-tech answer to the need for extended sleep behavior monitoring.¹⁰ Patients complete sleep diaries upon waking each morning, noting a number of variables such as the time they went to bed and fell asleep and any nighttime awakenings. Patients are usually asked to complete sleep diaries for at least 14 days, though they can continue to be used on an as-needed basis or through the length of treatment. The diaries provide information that can be calculated to estimate total sleep time, time in bed, and sleep efficiency. They also estimate a person's daily napping behavior and caffeine/alcohol use.

Insomnia Severity Index (ISI) The ISI¹⁶ is a 7-item self-report questionnaire aimed to evaluate sleep difficulties related to insomnia. It demonstrates good reliability and validity and is sensitive to perceive changes in sleep behavior over time (e.g., following targeted sleep treatment). The literature suggests that it is a valid tool for use both as an initial screening measure but also as an outcome measure to evaluate posttreatment insomnia symptoms.¹⁶

Measures of fatigue Many health care providers use fatigue questionnaires (such as the Multidimensional Fatigue Inventory¹⁷) with concussion patients, who often report symptoms of fatigue, irritability, and daytime sleepiness. However, fatigue questionnaires are not commensurate with reported sleep behavior or daytime sleepiness and additional sleep questionnaires are highly recommended.

Continued monitoring of symptom recovery including sleep and activity, though extremely important to concussion recovery, is largely absent from current treatment protocols.

Considerations in using traditional and novel sleep technologies in clinical settings

In answering the question regarding the types of sleep measures available to neurologists, there exist a number of both of low-tech and high-tech options. Traditional pencil-and-paper sleep measures provide several benefits to clinicians. Although the majority of standard sleep measures do not provide continuous monitoring of sleep behavior, the measures described above can provide a good overview of clinical sleep symptoms and can alert clinicians to any serious sleep disturbances at an initial intake appointment. If a clinician sees a patient on several occasions, most measures, such as the ESS and ISI, can be readministered to track symptoms or posttreatment outcomes over time. Moreover, for those who wish to address sleep specifically but are new to sleep assessment, most of the previously mentioned traditional sleep measures are user-friendly and easy to obtain from the publisher's Web site at little to no cost. Finally, for those who have concerns regarding the burden of administering self-report questionnaires to a concussed population, most pencil-and-paper questionnaires are short and quick to complete. As an added benefit to the clinician, these assessments are equally as simple to score and scores are often easy to interpret in terms of assessing clinical severity of symptoms.

Newer activity-monitoring technologies such as the FitBit and other devices can be particularly useful in outpatient settings as they fill a notable gap in continuous symptom recovery monitoring. Similarly, they may be appropriate in inpatient rehabilitation settings if the patient's level of insight allows him or her to use the device appropriately. Traditionally, state-dependent symptom measures were all that were available to clinicians. Continued monitoring of symptom recovery including sleep and activity, though extremely important to concussion recovery, is largely absent from current treatment protocols. These newer technologies, however, may serve as a complement to typical treatment in offering continuous sleep and activity monitoring that is independent of a patient's self-report of concussion symptoms. Obtaining continuous, objective data of a patient's sleep and activity is particularly important in concussion patients, where sleepiness and activity level can change on a daily basis and can be indicative of recovery. Moreover, sleep and activity behavior can be assessed outside of the health care facility and can be monitored at home, work, or school. Finally, this technology may have considerable effect on treatment planning. Clinicians can identify specific, objective sleep patterns and aim to adjust any noted sleep disturbance issues. There may also be a greater patient buy-in in that the data are easily accessible to patients and the devices are aimed to promote greater health behavior awareness.

Additional clinical considerations

In treating sleep disturbance in an outpatient concussion population, neurologists may also find themselves asking, "When do I refer to a sleep specialist?" It is important to note that empirical data to guide the answer to this question are limited, making it difficult to determine when a referral is necessary. Anecdotally, neurologists consider the persistence and severity of sleep disturbance symptoms in the context of other postconcussion symptoms. According to DSM-5 criteria,¹⁸ insomnia disorder (episodic) would not be diagnosed until after 4 weeks, and chronic insomnia disorder would not be diagnosed unless symptoms persisted for 3 months or longer. At minimum, self-monitoring (via the use of sleep diaries, for example) may be prudent to determine the nature and severity of symptoms over the first

Take-home points

- Sleep disturbance is prevalent and persistent after concussion.
- Because duration, pattern, and severity of sleep disturbances are likely to vary among patients, neurologists should become familiar with the breadth of sleep metrics that are currently on the market.
- There are a number of options available, both high- and low-tech, which can be used to monitor a patient's disturbed sleep over the course of concussion recovery.

few weeks postconcussion. Neurologists might use the following guidelines to aid in their decision: (1) The person's sleep disturbances have not improved or have worsened over the course of treatment. (2) The person's sleep problems are likely indicative of a sleep disorder such as hypersomnia, insomnia, circadian rhythm disorder, or sleep apnea. (3) If the clinician is uncomfortable with treating reported sleep problems, believes the patient's sleep issues are outside the scope of his or her clinical practice, or if patient's self-report sleep measure scores fall within a clinically elevated range (see table), he or she may refer to a sleep specialist. Sleep specialists can provide a comprehensive sleep assessment (including a PSG if indicated), determine the presence and severity of a sleep disorder, and initiate pharmacotherapy or behavioral sleep medicine strategies.

It is also important to note the distinction between the acute phase of concussion recovery and postconcussive syndrome. Literature on acute concussion symptom management is scant and there remain few guidelines for treating postconcussion syndrome. While further research is needed on sleep interventions in concussed patients, such strategies (e.g., cognitive-behavioral therapy for insomnia) are known to both improve sleep and alleviate related symptomatology, even in patients with comorbid medical and mental health conditions (i.e., chronic pain and depression¹⁹). Given that emerging literature suggests neuropsychiatric reasons for development of postconcussion syndrome, targeted approach of both concussion and mental health concerns through behavioral and pharmacologic treatments may of particular benefit in those diagnosed with postconcussion syndrome.

Though some of this information may be applied to inpatient rehabilitation patients, this article is largely aimed at concussed outpatients with few other comorbid medical concerns. Additional information on sleep disorders can be found in DSM-5,¹⁸ ICD-10,²⁰ or in a number of review articles.²¹

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C. Mosti was responsible for the original idea for the paper and for writing the majority of the manuscript. M. Spiers was responsible for continued edits on the paper and for substantial idea contribution. J. Kloss was involved with the ongoing editing process and contributed substantial input to the paper as it related to the sleep measures.

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