Concussion and sleep in adolescents

Identifying and appropriately managing sleep disturbances is a critical aspect of care for adolescents suffering from persisting postconcussion symptoms.

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ABSTRACT

Background: Concussions are common among adolescents, and disordered sleep may influence symptom severity and recovery. We explored how sleep–wake symptoms present in adolescents with persisting postconcussion symptoms and how sleep disturbances affect their recovery.

Methods: We conducted an exploratory study at the Adolescent Complex Concussion Clinic (G.F. Strong Rehabilitation Centre) to examine sleep-related issues in adolescents aged 12 to 18 years who had been treated at the clinic for persisting postconcussion symptoms. We reviewed the charts of 49 adolescent patients and conducted semi-structured interviews with 12 patients. The patients who were interviewed were from the same clinic but not specifically from the 49 chart-review patients.

Results: Seventy-one percent of patients reported moderate to severe tiredness/fatigue at intake. Sleep disturbances on the Rivermead Post Concussion Symptoms Questionnaire were positively correlated with restlessness, fatigue, and bedtime worrying. Three key themes were identified from the semi-structured interviews: persistent sleep disturbances, challenges related to restricted daily activities, and a desire for clearer explanations of care plans. In both the chart review and the interviews, difficulty initiating sleep, restlessness, and daytime impairment were prominent.

Conclusions: Our findings highlight the need for targeted assessment and management of sleep disturbances as an essential component of care for adolescents experiencing prolonged postconcussion symptoms.

Background

In Canada, pediatric mild traumatic brain injuries, commonly referred to as concussions, are highly prevalent—an estimated 35 000 children and adolescents aged 5 to 19 years sustained a concussion in 2022, and emergency department visits for these injuries have doubled in recent decades.[1,2] These numbers likely do not fully represent the true incidence, because many concussions are not reported. While most adolescents make a full recovery by 1 month, symptoms that persist beyond 28 days are referred to as persisting postconcussion symptoms. They affect 33% of pediatric patients at 1 month and approximately 15% to 20% at 3 months.[3] The high prevalence of persisting postconcussion symptoms among adolescents highlights the need for standardized protocols in concussion

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This article has been peer reviewed.

care[4] and a harmonized multidisciplinary approach. Adolescents and children respond differently to concussion than adults do, and they often have prolonged recoveries. Well-recognized risk factors for the development of persisting postconcussion symptoms include adolescence, female sex, anxiety or depression, history of migraines, headache as an initial symptom, fatigue, sensitivity to noise, and previous concussion with symptoms lasting longer than 1 week.[3,5] More recently, pre-existing sleep disorders have also been recognized as an independent predictor of persisting symptoms following concussion.[6]

Emerging research has identified sleep as a factor that influences symptom severity and the trajectory of concussion recovery; adolescents who suffer from sleep disturbances are more likely to have reduced quality of life, exacerbated symptoms, and prolonged recovery times.[7-10] Therefore, identifying and appropriately managing sleep disturbances is a critical aspect of care for adolescents with persisting postconcussion symptoms. However, in the community setting, sleep disturbances are often overlooked or not systematically evaluated due to limited access to sleep specialists and sleep testing; thus, they become a cause of systemic bias in clinical practice.[11] Despite many years of clinical reporting, it remains unclear whether postconcussion sleep disturbances are due to an underlying sleep disorder, poor sleep health (e.g., reduced duration of sleep, nonrestorative sleep) secondary to abrupt lifestyle changes after concussion,[12] or direct disruption of neural networks.

Our primary objective in this study was to explore the presentation and personal experiences of adolescents with persisting postconcussion symptoms who were referred to a quaternary-level interdisciplinary provincial concussion clinic based on a sleep–wake behaviors perspective. Our goals were (1) to explore how sleep–wake symptoms in adolescents with persisting postconcussion symptoms present in clinical practice and (2) to recognize the negative impact of sleep disturbances on postconcussion symptoms and patient perceptions of recovery. Although empiric evidence for the management of persisting postconcussion symptoms in adolescents remains limited, our qualitative exploratory study may provide information about the type of sleep challenges pediatric patients face after a concussion and thus reinforce the need for tailored management of sleep symptoms.

Sleep dysfunction is both a symptom of concussion and a risk factor for persisting postconcussion symptoms in adolescents.

Methods

We conducted our study at the Adolescent Complex Concussion Clinic (AC3) at the G.F. Strong Rehabilitation Centre, the only interdisciplinary provincial pediatric program that targets adolescents between the ages of 12 and 18 years who suffer from prolonged concussion symptoms and live in British Columbia, a province with approximately 1 million children and adolescents **[Box 1]**. We reviewed the charts of adolescent patients who had been treated at the AC3 for persisting postconcussion symptoms (University of British Columbia Behavioural Research Ethics Board ID H19-01186). We then conducted semi-structured interviews with AC3 patients to capture their lived experience with persisting postconcussion symptoms (University of British Columbia Behavioural Research Ethics Board ID H21-02911). The patients who were interviewed were from the AC3 clinic but not specifically from the chart-review patients.

Clinical presentations

Patient data collected prospectively included demographics (e.g., age, sex); concussion history (e.g., total number of concussions, date of most recent injury, most recent mechanism of injury); and sleep-related items from three standardized questionnaires completed at first presentation to the clinic: the Rivermead Post Concussion Symptoms Questionnaire (RPQ),[13] the Kutcher Adolescent Depression Scale (KADS),[14] and the Patient-Reported Outcomes Measurement Information System (PROMIS) anxiety scale.[15] We also analyzed patients' clinical reports to find indicators of the five domains of the explorative BEARS mnemonic: *B* stands for *bedtime* (exploring situations associated with disorders of initiating sleep), *E* stands for *excessive daytime sleepiness* (affected daytime functioning due to potential sleep disorders), *A* stands for *awakenings* (challenges with sleep maintenance), *R* stands for *routines/regularity*, and *S* stands for *snoring* (as the core symptom of sleep-disordered breathing).[16]

We used IBM SPSS Statistics to conduct our statistical analysis. Spearman's correlations were calculated to determine the relationship between "sleep disturbance" reported in the RPQ and other sleep–wake symptoms reported in the RPQ (e.g., "fatigue, tiring

BOX 1. Adolescent Complex Concussion Clinic (AC3), G.F. Strong Rehabilitation Centre.

The AC3 at the G.F. Strong Rehabilitation Centre was created in 2012 to provide provincewide interdisciplinary outpatient concussion treatment for youth 12 to 18 years of age with persisting postconcussion symptoms, coexisting risk factors or conditions, and complex presentations, which often prolong and complicate recovery.

Follow-up is provided for return to learning, sports, and social activities.

The AC3 team consists of occupational therapists, G.F. Strong School Program teachers, a pediatric and adolescent physical medicine and rehabilitation specialist, a physiotherapist, a neuropsychologist, and a social worker.

more easily"; "restlessness"), the KADS (e.g., "feeling tired, feeling fatigued, low in energy, hard to get motivated, have to push to get things done, want to rest or lie down a lot"), and the PROMIS anxiety scale (e.g., "I worry when I go to bed at night").

Semi-structured interviews

The results of the chart review guided the questions for the semi-structured interviews. Four categories of interest were identified: (1) concussion experiences and symptoms directly following the most recent concussion; (2) persistent symptoms, including sleep difficulties in follow-up; (3) treatment-related patient perspectives, with a focus on the patient's involvement in decision making; and (4) willingness of the patient to participate in future research, given their individual experiences.

Inclusion criteria required participants to be former AC3 patients who had been treated between the ages of 12 and 18 years, were between 13 and 30 years at the time of the interview, and were fluent English speakers. Participants were recruited via email invitation. Once a potential participant expressed interest, research assistants scheduled a phone conversation to review the consent/assent forms and ensure their comprehension. Assent was obtained from participants aged 13 to 18, in conjunction with parental consent. Consent was obtained only from participants aged 19 or older. Participants received $25 in compensation. Two research assistants conducted the interviews using the university-licensed version of Zoom. Both video and audio were recorded for transcription and stored via Zoom cloud recordings. Transcripts were anonymized, and three research assistants analyzed the data using descriptive statistics for each domain (demographics, symptoms, sleep disturbances, perception of treatment, future research) and category/question (e.g., keywords used repeatedly).

TABLE. Characteristics of study participants treated at the Adolescent Complex Concussion Clinic.

Characteristic	*n* (%)
Age	Mean: 15 ± 1.7 years
Male/female	25 (51)/24 (49)
Time from last concussion to intake	Mean: 3.4 ± 3.7 months
Cause of concussion	
Sport/recreation (e.g., "hit head on ice while playing hockey," "thrown from a horse")	38 (78)
Transport (e.g., "collided with a car while bicycling")	6 (12)
Head struck object (e.g., "hit head on metal door," "hit head against iron ladder")	5 (10)
Number of concussions	Mean: 2.7 ± 1.5
1	12 (25)
2–5	34 (69)
≥ 6	3 (6)
Additional sleep items (BEARS)	
Bedtime	19 (39)
Excessive daytime sleepiness	33 (67)
Awakenings	8 (16)
Routines/regularity	26 (53)
Snoring	1 (2)

Results

Clinical presentations

In total, 50 patient charts were reviewed. One patient was excluded due to missing chart information; therefore, 49 patients (aged 12 to 18 years at the time of treatment) were included in the study. Using the BEARS screening concept, 43/49 (88%) patient charts reported altered sleep–wake behaviors **[Table]**.

The most prevalent sleep–wake issues identified by the sleep-related items on the questionnaires were "fatigue, tiring more easily" on the RPQ—reported as moderate or severe (on a scale of not experienced, mild, moderate, or severe) by 71% of patients—and "feeling tired, feeling fatigued, low in energy, hard to get motivated, have to push to get things done, want to rest or lie down a lot" on the KADS questionnaire, which affected 70% of patients most or all of the time (on a scale of some, much, most, or all of the time). Thirty-three percent of patients rated "restlessness" as moderate or severe on the RPQ.

"Sleep disturbance" was positively correlated with "restlessness" on the RPQ (Spearman's $r = 0.554$, $P < .01$); with "feeling tired, feeling fatigued, low in energy, hard to get motivated, have to push to get things done, want to rest or lie down a lot" on the KADS questionnaire (Spearman's $r = 0.566$, $P < .01$); and with "I worry when I go to bed at night" on the PROMIS anxiety scale (Spearman's $r = 0.360$, $P < .05$).

Semi-structured interviews

We conducted interviews with 12 patients (mean age = 18.67 years; eight males and four females) **[Figure 1]**. All of them led active lifestyles: five participants played contact sports, and the others participated in noncontact sports. All but two participants had experienced a sport-related concussion. On average, 12% of the interview time was spent discussing sleep (range = 6% to 23%).

Nighttime experiences: When asked about their sleep prior to their concussions, only two participants reported having difficulty sleeping. Following their concussions, all

12 participants reported at least two nighttime symptoms that affected their sleep **[Figure 1]**. One participant mentioned their sleep experiences only once, but when asked about their nighttime symptoms, they reported difficulty falling asleep (up to 1 hour), nighttime restlessness in their lower limbs, and nightly awakenings.

Participant statements were selected based on their clarity and relevance. One participant, who suffered two concussions from playing lacrosse, elaborated on their insomnia experiences when asked about sleep changes prior to and following their concussion and identified their main difficulties: "I could sleep pretty well before; it would take me like 15 minutes to fall asleep, which was like pretty good, but after my concussions, and still kind of now, it takes me about an hour to fall asleep, or like half an hour if I'm like really tired, but I can never fall asleep right away. I'm always moving my legs. I don't know what I'm doing . . . just when I'm sleeping, my legs are just always moving for a while. I don't know why."

Daytime experiences: Irritability was the most common daytime symptom, followed by headaches, sensitivity to light and noise, memory disturbances, fatigue, fidgeting/restlessness, dizziness, and posttraumatic stress symptoms **[Figure 1]**. One participant described daytime and nighttime irritability and restlessness as a continuum: "I needed a lot—a lot—of sleep. But I wouldn't be able to sleep, like I wouldn't be able to, you know, be able to fall asleep. I would be a little restless, and I was very irritable. That's another symptom. So I was always hyperactive and agitated in my head. Never very calm."

Lifestyle experiences: All participants described how their lives were affected by limitations. Seven participants experienced challenges returning to school following their concussions, with three of them mentioning that the school setting increased the severity of their symptoms. One participant expressed the emotions associated with their new limitations: "More of kind of like anxiety, in a sense. . . . I wasn't as outgoing, type of thing. I kind of more kept to myself. . . . When I got [the concussion], it kind of like took me out from playing sports and everything; it kind of just like built up even more."

Experiences with treatment: Nine of the 12 participants felt adequately involved in decisions about their treatment. The other three either did not feel involved, felt they were not involved because of their age, or were not asked during their interview.

Discussion

Given the high prevalence of adolescent concussions in Canada[1] and the association between concussions and sleep disturbances,[17] we explored how sleep–wake symptoms present in adolescents with persisting postconcussion symptoms and how sleep disturbances affect their recovery. To our knowledge, this is the first report of semi-structured qualitative interviews conducted with adolescents who suffer from persisting postconcussion symptoms. A review of national and provincial concussion guidelines that include the pediatric population **[Figure 2]** identified sleep as a main consideration in the management of concussions.[18-20]

Our data showed that daytime impairments, which were captured by questions about tiredness, fatigue, and the need to rest or lay down, were the most significant sleep–wake symptoms reported on two separate questionnaires at the time of initial consultation, with 71% of the chart review patients rating these symptoms as moderate or severe and 70% stating they occurred most or all of the time. Additionally, 88%

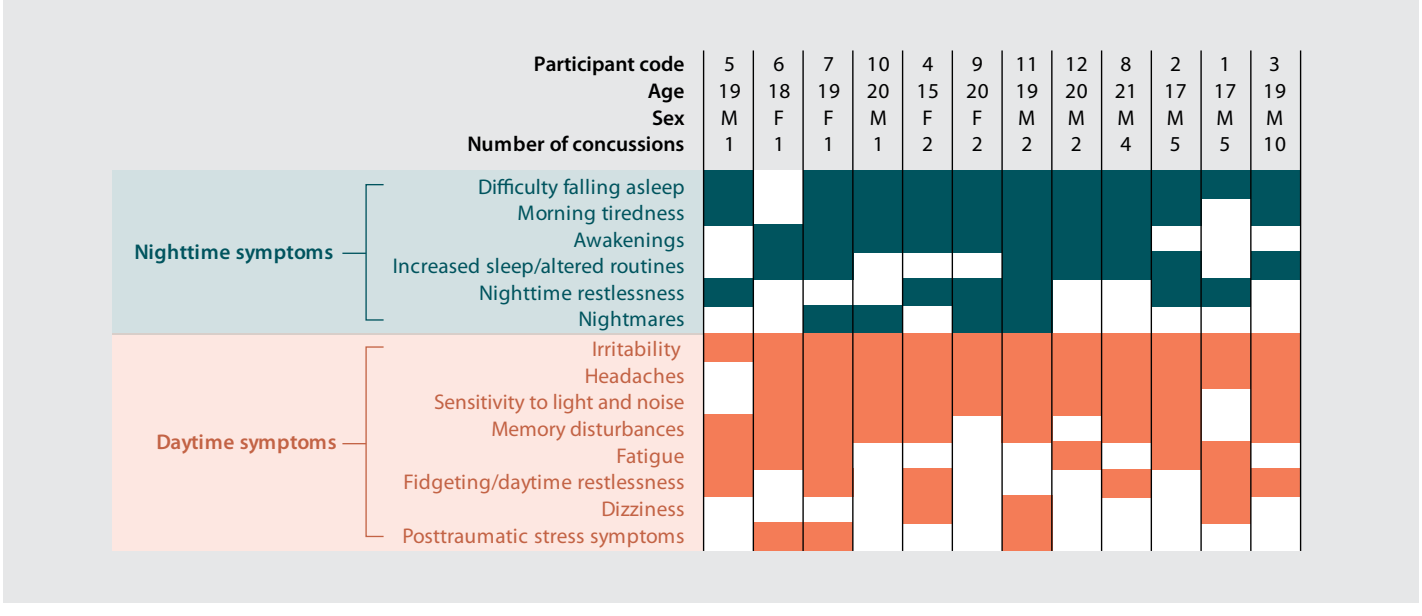

FIGURE 1. Postinjury symptoms reported by interview participants.

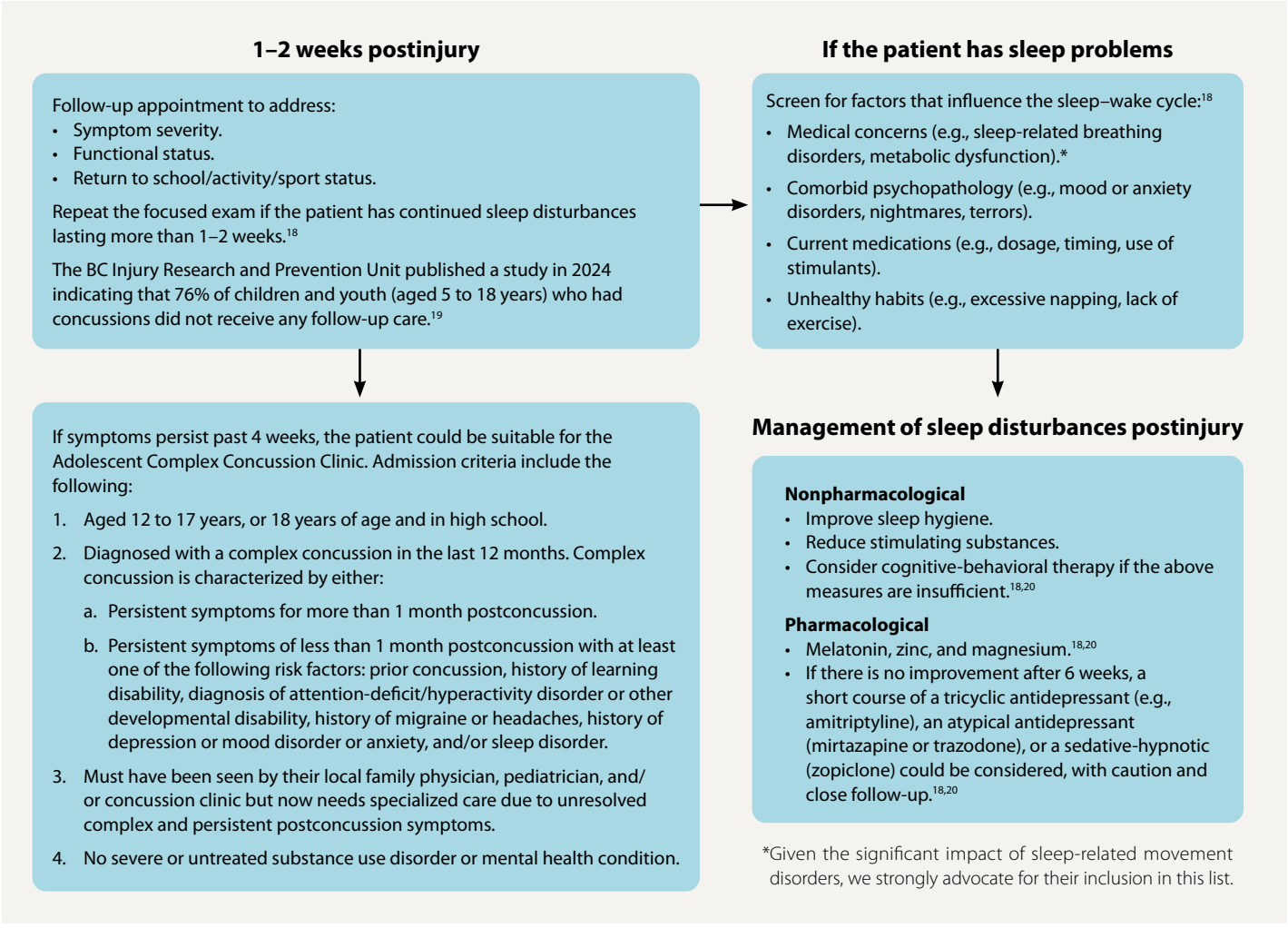

FIGURE 2. Summary of national and provincial concussion guidelines that include pediatric populations.

of the chart review patients had at least one altered sleep–wake behavior based on the explorative BEARS screening concept. Evidence has shown that sleep dysfunction is both a symptom of concussion and a risk factor for persisting postconcussion symptoms in adolescents.[6,21] Notably, Milewski and colleagues found that middle school and high school athletes who slept less than 8 hours per night were 1.7 times more likely to sustain a sport injury, including a concussion.[22] This raised the question about whether screening athletes for sleep disturbances and providing sleep health counseling would reduce the incidence of concussion in this population **[Box 2]**, particularly considering the increased attention on concussion education and awareness among interested parties.[23]

Persisting postconcussion symptoms can significantly affect school, leisure, and socialization. This often leads to frustration, anxiety, and/or depression,[24] which were common themes identified in our interviews. Moreover, anxiety and depression have been shown to be positively associated with reduced sleep quality following concussion.[25] Another major theme we identified based on the interviews was persistent sleep disturbances following concussion. When we investigated adolescents' perspectives on the effects of concussion and/or persisting postconcussion symptoms on their lived experiences, each participant reported at least two sleep-related symptoms postconcussion. Difficulty falling asleep and morning tiredness were the most common complaints. Seventy-five percent of interview participants reported experiencing either daytime or nighttime restlessness, which was strongly correlated with sleep disturbance. Restlessness has several differential diagnoses. During the daytime, it may be associated with attention-deficit/hyperactivity disorder, whereas during periods of rest or during transitions from wakefulness to sleep, it may be due to sleep-related movement disorders, such as restless legs syndrome or periodic limb movements in sleep. Walker and colleagues reported an increased prevalence of restless legs syndrome in adults following concussion compared with a control group (32.0% vs 2.7%).[26] To our knowledge, no study has investigated restless legs syndrome in the pediatric population, either as a pre-existing but

unrecognized condition or as one that is unmasked after concussion. The impact of restless legs syndrome on daytime functioning is substantial. It has been shown to have a negative influence on children and adolescents' mood and irritability, and it has been linked to higher rates of suicide and self-harm in adults.[27,28]

The relationship between sleep and concussion is likely bidirectional and is not easily diagnosed at a primary care level. The lack of readily available and accessible overnight sleep testing to objectively measure sleep architecture, sleep phase disturbances, arousability, and breathing makes diagnosis and management challenging, even at a specialty clinic level.

The final theme we identified from the interviews was that adolescents yearned for explanations, despite generally feeling adequately involved. Prioritizing the patient rather than the injury in collaborative assessments of persisting postconcussion symptoms promotes meaningful interactions with pediatric patients, their parents, and interdisciplinary professionals.[29] This also highlights the need for shared language and support for our youth as they navigate health care, as demonstrated by the use of the PROMIS anxiety scale at the AC3 to capture individualized patient-reported outcomes.

Study limitations

We reviewed concussions in the adolescent population from both sleep and rehabilitation medicine perspectives. Both perspectives identified significant functional burden during school and daytime activities due to daytime impairment and sleep dysfunctions.

The AC3 did not use a sleep-specific questionnaire, and the sleep-related questionnaire items used are not semantically specific enough. The questionnaires assess restlessness, impaired daytime functioning, and difficulty falling asleep, but they leave other important areas of sleep medicine to be covered by a single question on the RPQ about "sleep disturbances." Data from only one clinic were reviewed. In both our chart reviews and interviews, the number of patients was limited. Despite collecting information according to a prospective protocol, the available clinical data were collected retrospectively, and some charts were incomplete. The time between the most recent injury and assessment at the clinic was not standardized, despite all patients being assessed months after their last concussion. Further, comprehensive follow-up data are missing, which makes it difficult to review many symptoms of interest (e.g., sensory discomfort, pain, balance). We can expect that sleep disturbances would be even more common in this collective, given that formal sleep assessments were not conducted and a validated sleep questionnaire was not used.

BOX 2. Recommendations for systematic sleep health screening.

Current guidelines recognize pre-existing sleep disorders as predictors of persistent postconcussive symptoms and frame sleep as a therapeutic target following concussion. However, they do not provide proactive recommendations for systematic sleep health screening prior to injury.

In routine practice, sport stakeholders receive educational materials that describe concussion definitions and mechanisms; symptom recognition; prevention strategies; and recommended management pathways, including return-to-school, return-to-sport, and medical clearance requirements.[23] From both knowledge dissemination and injury prevention perspectives, we propose a stepped-care approach that begins with brief screening for impaired daytime functioning related to pre-existing sleep disturbances or sleep disorders prior to participation in organized sports or physical activities. This recommendation aligns with the sleep–wake framework of the World Health Organization's *International Classification of Diseases*, 11th revision (ICD-11), which conceptualizes sleep and wakefulness as integrated and interdependent processes. As an initial step, sport stakeholders could ask the following screening questions:

- Are your physical performance and/or daytime functioning affected by your sleep?
- How do you feel upon awakening? Do you feel refreshed after sleep?
- How would you describe your sleep?
- How many hours of sleep do you get per night, on average?

Any identified red flags should prompt presentation to a primary care provider for a structured sleep history. This assessment should include familial sleep history, early childhood sleep patterns, and systematic screening across the six major sleep–wake disorder categories defined in the ICD-11:

1. Insomnia disorders.
2. Hypersomnolence disorders.
3. Sleep-related breathing disorders.
4. Circadian rhythm sleep–wake disorders.
5. Sleep-related movement disorders.
6. Parasomnia disorders.

Such a proactive strategy may strengthen both primary and secondary prevention in sport-related concussion management by establishing baseline sleep health, reducing vulnerability to sport-related injury, and potentially lowering the risk of prolonged recovery.

Conclusions

Functional impairment during the daytime, difficulty falling asleep, and restlessness were strikingly common themes across both patient chart reviews and interviews in our exploratory study. Identification and appropriate management of sleep disturbances is a critical aspect of care for adolescents who suffer from postconcussion symptoms. The first step toward harmonizing concussion care is ongoing evaluation of clinical practices. ■

Funding

Funding for the semi-structured interviews was awarded to Dr McWilliams by the Canadian Sleep Society/Canadian Sleep and Circadian Network Trainee Project 2021 Grant.

Competing interests

None declared.

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