Wake up call for collegiate athlete sleep: narrative review and consensus recommendations from the NCAA Interassociation Task Force on Sleep and Wellness

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Abstract:

Sleep is an important determinant of collegiate athlete health, well-being and performance. However, collegiate athlete social and physical environments are often not conducive to obtaining restorative sleep. Traditionally, sleep has not been a primary focus of collegiate athletic training and is neglected due to competing academic, athletic and social demands. Collegiate athletics departments are well positioned to facilitate better sleep culture for their athletes. Recognising the lack of evidence-based or consensus-based guidelines for sleep management and restorative sleep for collegiate athletes, the National Collegiate Athletic Association hosted a sleep summit in 2017. Members of the Interassociation Task Force on Sleep and Wellness reviewed current data related to collegiate athlete sleep and aimed to develop consensus recommendations on sleep management and restorative sleep using the Delphi method. In this paper, we provide a narrative review of four topics central to collegiate athlete sleep: (1) sleep patterns and disorders among collegiate athletes; (2) sleep and optimal functioning among athletes; (3) screening, tracking and assessment of athlete sleep; and (4) interventions to improve sleep. We also present five consensus recommendations for colleges to improve their athletes' sleep.

Keywords: sleep habits | collegiate athletes | academic success |

Article:

What is already known

- Sleep is an important determinant of collegiate athlete health, well-being and performance.
- Collegiate athletes often neglect sleep because of academic, athletic and social demands.

What are the new findings

- College athletic departments can take steps to promote collegiate athlete well-being and performance through sleep by:
  - Conducting an annual time demands survey.
  - Incorporating sleep screening into the preparticipation exam.
  - Providing evidence-based sleep education to collegiate athletes and coaches.

Introduction

Sleep is critical for overall health and well-being. The Healthy People 2020 objectives, a set of 10-year national objectives for the health of all Americans, prioritised sleep and set out objectives to increase sufficient sleep, increase diagnosis and treatment of obstructive sleep apnea and prevent accidents due to drowsy driving.[1] Poor sleep disproportionately negatively impacts those in late adolescence through their early 20s (emerging adults).[2] The relationship between sleep duration and cardiometabolic risk and neurocognitive dysfunction is especially pronounced among young adults.[3] Although fewer studies have focused on collegiate athletes, the documented outcomes of insufficient sleep duration, poor sleep quality (restorative sleep) or both include many critically important domains, spanning physical and academic performance, cognitive function, recovery from athletic exertion and injury, mental health and cardiometabolic health. Collegiate athletes' social and physical environments are often not conducive to obtaining restorative sleep. Furthermore, their academic and athletic schedules may vary due to travel, practice and game schedules, different meal schedules, mandatory team meetings or other factors, all of which can prevent consistent bed and rise times.

Good sleep hygiene practices are summarised in box 1.[4] A 2015 survey of National Collegiate Athletic Association (NCAA) collegiate athletes found that they spend 27–41 hours per week on athletics.[5] After allowing time for academics, other extracurricular activities and relaxation or socialising, few have sufficient time left for restorative sleep.[5] In addition, collegiate athletes often practice poor sleep hygiene habits. Caffeine, alcohol, marijuana and other illicit drugs and non-medical use of prescription drugs such as stimulants all can interfere with neurochemical control of sleep.[6] Evening use of electronic devices suppresses melatonin levels and increases alertness, both of which delay sleep onset and contribute to sleep deprivation.[6] These behaviours are compounded by student housing environments that can be too loud, bright, or crowded for consistent restorative sleep.[7]

Elite athletics programmes are beginning to recognise that collegiate athlete health and performance can be improved through sleep optimisation.[8 9] In May 2017, the NCAA convened the Interassociation Task Force on Sleep and Wellness, which consisted of sleep experts, coaches, collegiate athletes, athletic administrators and educators who met to address this issue (supplementary table 1). This meeting indicated the potential for collegiate athletics departments to help improve their athletes' sleep.

In this study, we aimed to obtain consensus on useful and feasible sleep-supportive strategies for collegiate athletics departments. Guided by the Delphi method, we began this process with a

narrative review of the following topics: epidemiology of sleep in sport; sleep and optimal functioning among athletes; screening, tracking and assessment of athlete sleep; and interventions to improve sleep. In reviewing literature across these topic areas, the goals were to provide an overview for individuals working with athletes in collegiate sport and other sport settings and to provide a foundation for consensus recommendations regarding sleep for athletics departments.

Box 1. Sleep hygiene guidelines

1. Maintain a regular sleep schedule as much as possible, including on weekends. If this is not possible due to situational demands, establish a bedtime routine that can be practised regularly.
2. Seek bright light during the day, especially the morning, and avoid bright light at night if possible. This is especially important later at night, when bright light can further delay sleep onset.
3. Keep the bedroom should be kept cool, dark and comfortable.
4. Avoid caffeine (eg, coffee, energy drinks and certain types of soda and tea) at least 6 hours before bedtime. Nicotine is also a stimulant and should be avoided. Alcohol may reduce time to fall asleep, but it can adversely impact sleep quality and should be avoided close to bedtime.
5. Avoid consuming excessive food and liquids at night as these may disrupt sleep through reflux and increased trips to the bathroom.
6. Avoid obsessive clock watching. Often, looking at the clock at night can increase mental activity rather than decrease it and make resuming sleep more difficult.
7. Individuals who have difficulty falling asleep should generally avoid naps. However, collegiate athletes may find that napping during the day may improve performance and functioning.
8. Use beds for sleep (and sex) only. Any other activities, especially if lying awake and unable to sleep, should be done out of the bed. Those who have difficulty falling asleep should get out of bed for a period of time and try again later. This practice (called stimulus control) is supported by strong evidence that it will help prevent insomnia and improve sleep quality over time.

Methods

The Delphi method provides a comprehensive, efficient and unbiased way of aggregating expert opinion that allows multiple stakeholders to have a voice.[10] Consistent with best practice guidance for using the Delphi method, our process included exploration and evaluation phases,[10] as described below.

Exploration phase

Content experts conducted a narrative review of: (1) sleep patterns and disorders among collegiate athletes; (2) sleep and optimal functioning among collegiate athletes; (3) screening, tracking and assessment of collegiate athlete sleep; and (4) interventions to improve collegiate athlete sleep. PubMed, Scopus and Cochrane CENTRAL databases were searched using these

subject headings and keywords: ‘Sleep’, ‘Sports’, ‘Injuries’, ‘Adolescents’, ‘Collegiate’, ‘Exercise’, ‘Mental Health’, ‘Performance’, ‘Athlete’, ‘Screening’, ‘Technology’, ‘Assessment’, ‘Tracking’, ‘Consumer’, ‘Subjective’, ‘Objective’, ‘Questionnaires’, ‘Sleep-Disordered Breathing’, ‘Insomnia’, ‘Narcolepsy’, ‘Circadian’, ‘Disorders’ and ‘Review’. Pearling of articles was also performed to find related references. Articles were chosen if they focused on sleep and collegiate athletes. For some topics, little or no published literature was available for collegiate athletes, but relevant literature was available for college students, emerging adults and competitive athletes in general. In such instances, we broadened our selection criteria to include literature focusing on these related populations. Studies published before 1 June 2018 were included and no study design limits were applied in any searches.

Evaluation phase

Based on the results of this review, an internal working group prepared foundational action-oriented recommendations for collegiate athlete sleep to implement in collegiate sport settings. Content experts contributing to the narrative review provided initial feedback about these recommendations to ensure scientific appropriateness and clarity. Recommendations were modified, as needed, based on this feedback. Next, members of a multidisciplinary panel group who attended the NCAA’s Interassociation Task Force on Sleep and Wellness were emailed the narrative review and a link to an anonymous online survey for scoring the recommendations. Members of the panel included content experts (sleep researchers and individuals who develop and implement sleep-related policy and programming) and stakeholders affected by the recommendations (eg, coaches, collegiate athletes and athletic administrators).

Drawing on the narrative review and their own expertise, panel members scored each recommendation on utility and feasibility.[10 11] *Utility* was defined as whether the recommendation, if implemented, was likely to improve any aspect of collegiate athlete sleep. *Feasibility* was defined as the degree to which individuals or campuses would be able to implement the recommendation. For each dimension, scores were elicited on a nine-point scale, with higher scores indicating that the recommendation is more useful/feasible. Panel members were also invited to provide written comments about each recommendation. After panel members completed this process, mean scores for each recommendation were calculated separately for utility and feasibility. Any recommendations with a rounded mean score of 3 or less on either dimension were discarded, and any with a rounded mean score of 7 or more on both dimensions were included in the final product. Recommendations that received a rounded mean score >3 but <7 on either dimension were revisited.[11]

Panel members’ comments were reviewed and potential modifications to the statements (or potential additional support for implementation to address feasibility) were generated based on these comments. Content experts were subsequently invited to provide additional feedback on the proposed modifications and implementation support. The internal working group synthesised this feedback and final modifications were made to the recommendations. As with the first round of scoring, panel members were emailed a link to an anonymous online survey in which they scored each recommendation that was modified or did not achieve consensus during the prior round of scoring. This second round of data were analysed as in the first round. Recommendations that the panel determined to be useful and feasible were presented as the final

product of this process. NCAA Research Review Board approval was obtained for the Delphi consensus process.

Narrative review

Epidemiology

The American College Health Association's annual National College Health Assessment (NCHA) survey includes information about sleep behaviour and allows researchers to aggregate results by students who self-identify as varsity athletes.[12] Among 14 134 collegiate athletes at NCAA member institutions, 61% reported daytime fatigue at least three or more days in the past week, and others reported consistent or more serious sleep difficulties (table 1). These data are similar to those in non-athletes,[12] suggesting lack of sleep is endemic among all college students.

Table 1. National College Health Assessment: self-reported sleep behaviour among full-time undergraduate students who self-identify as varsity athletes at NCAA member Institutions (n=14 134)[12(p20)]

Sleep behaviours	Reported response option	Percent of varsity athletes
Sleep difficulties in the past 12 months.	Traumatic or very difficult to handle.	24
Falling asleep at night.	Extreme difficulty at least three nights in the last week.	24
Awaking too early and unable to go back to sleep.	Occurred at least three nights in the last week.	16
Getting enough sleep to feel rested.	Insufficient sleep more than 3 days out of past 7; Insufficient sleep 6–7 days out of past 7.	57 23
Daytime tiredness.	Felt tired, dragged out or sleepy at least 3 days during the last week; reported that daytime sleepiness has been a big problem in last 7 days.	61 17
Negative consequences of sleep difficulties.	Academic performance.	18

In a recent single-institution study of 628 collegiate athletes from 29 varsity teams, 42% experienced poor sleep quality (measured by the Pittsburgh Sleep Quality Index) and 51% reported high levels of excessive daytime sleepiness (assessed by the Epworth Sleepiness Scale).[13] Similarly, in the NCAA Growth, Opportunities, Aspirations and Learning of Students survey (GOALS),[5] less than 25% of collegiate athletes reported ≥8 hours of sleep on a typical night (supplementary table 2). Poor sleep quality was also prevalent, as 19% of male and 23% of female respondents reported difficulty sleeping at least 8 of the past 30 days (see supplementary table 3 for a breakdown by NCAA division). Moreover, 70% of male and 82% of female collegiate athletes reported a preference for more sleep. In sum, epidemiological data suggest that inadequate sleep quality and quantity could be targeted for improvement among collegiate athletes.

Sleep and optimal functioning

Athletic performance

Data are limited regarding the influence of sleep disturbance, sleep deprivation or circadian desynchrony on athletic performance.[8 9 14–16] Poor sleep is associated with delayed reaction time, increased perceived effort, fatigue, mood disturbance and reduced time to both exhaustion and task failure; however, it does not affect physiological markers of anaerobic, aerobic or power output.[8 14 17] Interestingly, sleep-deprived athletes may be able to execute or perform required sport-related tasks, but their task-related cognitive and psychological tolerance is diminished, thereby increasing perceived effort and somatic symptom reporting.[18] However, data on the overall physiological effects of sleep impairment and its dose–response relationship on endurance performance, anaerobic power, and sprint performance are conflicting. The data are derived from small samples with inconsistent methods to measure strength and performance.[8]

As described in greater detail in a subsequent section, few studies have evaluated the effects of sleep extension on athletic performance. However, some studies have shown that serving accuracy, shooting accuracy and reaction time significantly improve in collegiate tennis and basketball players, respectively, following objectively measured sleep extension beyond 8 hours per day for several weeks.[19 20] Although regular exercise improves sleep quality, duration and efficiency,[21] the relationship between training loads, sleep and performance is complex and poorly understood. Sport-specific tasks and individual responses to training and sleep are likely different enough that optimising performance in athletes will require individualised approaches and further research.

Injury and illness

Adolescent athletes who reported sleeping <8 hours per night were 1.7 times more likely to have a musculoskeletal injury,[22] while sleeping >8 hours during weekday nights was associated with 61% lower odds of such an injury.[23] Similarly, a simultaneous increase in training load, training intensity and decreased hours of sleep resulted in a significantly higher risk of injury.[24] College students with poor quality sleep also report significantly more medical illness than those with near-ideal or ideal sleep (as determined by an aggregation of factors including sleep quality and duration).[25] One potential mechanism may be that increases in proinflammatory cytokines following sleep loss could promote immune system dysfunction.[26]

Mental health

Sleep disturbances are clinically relevant for evaluation and treatment of mental health conditions in collegiate athletes.[6 27 28] The relationship between mental health and sleep quality are bidirectional and interdependent: poor sleep exacerbates mental health disorders and negative mood, and stress and mental health disorders lessen sleep quality and quantity.[29] The most commonly reported barrier to sleep among college students is perceived stress.[25] Among individuals with clinically relevant manifestations of depression and anxiety (25% of all collegiate athletes[30]), sleep disturbances include difficulty with sleep initiation and maintenance, circadian rhythm dysregulation and insomnia or hypersomnia.[31]

In the 2018 American College Health Association (ACHA)-NCHA dataset, collegiate athletes with self-identified sleep problems were more than twice as likely to report feeling overwhelming anxiety, being so depressed it was difficult to function and considering suicide in

the last 30 days compared with athletes who did not indicate sleep disturbance.[12] Prospective population studies demonstrate that disturbed sleep predicts development of anxiety and depression in adolescents.[32] In adults, anxiety and depression at baseline predict new cases of insomnia, and insomnia at baseline predicts new diagnoses of anxiety and depression 1 year later.[33] Similarly, treating insomnia improves depression and anxiety symptoms, and treating anxiety/depression improves insomnia.[34] In both students with depression and anxiety and healthy college students, better sleep is associated with improved mental wellness.[35 36]

Academic performance

Better sleep is associated with greater academic success perhaps in part because acute sleep deprivation impairs cognitive performance and protracted insufficient sleep exacerbates mood disorders and distorts emotion regulation.[28 37–39] In general, students with better sleep (eg, >7 hours of night-time sleep, more consistent sleep schedules, lower levels of daytime sleepiness and less weekend 'catch-up' sleep) report higher grade point averages (GPAs).[28 37–39] Multiple single-institution prospective and cross-sectional studies have shown that insufficient, inconsistent and/or poor quality (non-restorative) sleep independently predict college students' academic performance, even after accounting for other measures of achievement like standardised test scores.[28 37] In a study of 1845 undergraduates, those screening positive for possible sleep disorders were significantly more at risk for academic failure (GPA <2.0).[40] Among respondents in the 2009 ACHA-NCHA survey, sleep disturbances (early awakening, insufficient sleep or difficulty falling asleep) independently predicted poor academic performance, on par with high-risk drinking in its association with GPA and course completion. On average, each additional day per week a student reported experiencing sleep problems raised the probability of dropping a course by 10%.[41]

Screening, assessment and tracking

Sleep measurement can be either subjective, assessed mostly through questionnaires, or objective, occurring in either a sleep laboratory or at home (see supplementary table 5). Objective testing can be further subdivided into 'clinical grade' measurements that are Food and Drug Administration (FDA) approved to assess and diagnose sleep disorders, or 'consumer-based',[42 43] which lack FDA approval but can measure sleep continuously in the subject's typical sleeping environment. The clinical sleep laboratory environment, where detailed objective testing such as polysomnography[44] and multiple sleep latency testing[45] occur, has the advantage of accuracy and detail, and the disadvantage of an atypical sleeping environment, which can influence the sleep it intends to measure. Furthermore, this testing only occurs during a discrete period of time. Objective sleep assessment can also occur in the home environment, which has the advantage of familiarity and longitudinal measurement but has the disadvantage of limiting the number of possible measures and compromised accuracy compared with sleep laboratory measures.

Tools for screening, assessment and tracking

In general, subjective screening questionnaires[44–58] and objective clinical-grade measurements[44,45, 57, 59, 60] focus on the diagnosis and treatment of sleep disorders such as sleep-

disordered breathing (eg, obstructive sleep apnoea), insomnia, narcolepsy and circadian rhythm sleep disorders. The presence of these and other sleep disorders may be tested in collegiate athletes during their preparticipation physical exam or in those seeking diagnosis and treatment for sleep problems. Sports medicine team members can also use subjective measures (see supplementary table 5) to refer collegiate athletes to team physicians, licenced mental health providers and board-certified sleep medicine professionals. These specialists can diagnose sleep disorders using clinical-grade objective measurements and implement treatment plans.

When screening athletes for disordered sleep, it is important to obtain a thorough sleep history. Key issues to address are summarised in box 2.[61] Current sleep habits describe bedtimes; awakening history; napping; and exposure to light, dark and electronic device use. Sleep quality includes a subjective assessment of 'average sleep', feeling rested and presence of daytime fatigue or somnolence. Family medical history should screen for a history of insomnia, narcolepsy, sleep apnoea, depression, anxiety, attention deficit hyperactivity disorder or other psychiatric disorders (eg, somatoform disorders, substance abuse and personality disorders). A sleep diary can be a valuable tool for establishing baseline sleep habits and identifying changes in hygiene practices.

Box 2. Key issues to address in conducting a sleep history

1. Current sleep schedule on weekdays and weekends:
2. Bedtimes.
3. Wake times.
4. How long to fall asleep.
5. Napping (number, timing and duration).
6. Sleep quality:
    a. Number of nightly awakenings and reason.
    b. Presence of sleep onset or sleep maintenance insomnia (early morning awakening with trouble falling back asleep).
    c. Wake with alarm or spontaneously.
    d. Waking feeling rested.
    e. Presence and extent of daytime sleepiness.
7. Sleep disorders:
    a. Presence of hypnagogic or hypnopompic hallucinations, sleep paralysis or cataplexy.
    b. Presence of restless leg symptoms (night-time leg discomfort relieved by movement).
    c. Sleep walking, confusional arousals or night terrors.
    d. Snoring, witnessed apnoeas, nocturnal choking and gasping or shortness of breath.
8. Medication and drug use:
    a. Use of stimulants.
    b. Use of sedative hypnotic medications.
    c. Recreational drug and alcohol use.
9. Mental health status.
10. Environmental conditions:
    a. Exposure to light.
    b. Electronic device use.

The emergence of consumer sleep technologies holds great promise for helping athletics departments better understand, and thus improve, collegiate athlete sleep.[42 43] Their ability to measure sleep in the collegiate athletes' home environment over time provides a heretofore unattainable ecologically valid measure of sleep. Consumer sleep technologies can also identify problematic sleep that may indicate a sleep disorder. Despite the value of these technologies to coaches, team physicians and collegiate athletes, their use assisting medical providers in diagnosing sleep disorders is evolving and not yet mature. However, they can currently help collegiate athletes and their support team to understand their sleep environment, duration and timing and can provide a baseline on which these collegiate athletes can improve.

Implementation of screening, assessment and tracking

One challenge in achieving collegiate athlete sleep health is determining the party responsible for screening, assessment and tracking of sleep beyond the athlete themselves. This group includes coaches, strength and conditioning specialists, team physicians, athletic trainers and psychologists. In some settings, strength and conditioning specialists are responsible for collecting subjective and objective collegiate athlete sleep data. They then relay the information and communicate with other clinicians/practitioners such as athletic trainers, team physicians and psychologists. Together, these professionals can provide the necessary support and expertise to the collegiate athlete to optimise his or her sleep health.

When considering the use of consumer sleep technologies, ethical issues of privacy, including who has access to the sleep data, and informed consent are hurdles that need to be cleared. Any sleep-monitoring programmes should be voluntary for collegiate athletes and include sleep health and performance education. Coaches and medical personnel should thoroughly investigate data supporting the accuracy and functionality of any consumer sleep technologies before collegiate athletes use them.

Interventions to improve sleep

Evidence-based approaches to improving sleep include behavioural, social and pharmacological interventions. Here we review how they apply to collegiate athletes, noting that in many instances the evidence base is primarily among college students more generally. Nearly three-quarters of college students report receiving no health education from their universities about how to manage sleep difficulties.[12] Interventions are particularly important for collegiate athletes who struggle to practice good sleep hygiene due to heightened time demands and for whom poor sleep impairs both academic and athletic performance. Unique elements of the collegiate athlete experience may present important opportunities for population-specific tailoring of educational messaging. For example, less than one-quarter of NCAA Division I collegiate athletes at a single institution regarded sleep as a way to recover from a game.[62] Knowledge translation about sleep's positive impact on athletic performance is an important starting point for population-tailored educational interventions.

The most common non-pharmacological sleep interventions studied in college-aged populations[63–65] include cognitive–behavioural therapy for insomnia (CBT-I), sleep hygiene and education and relaxation/mindfulness. In general, CBT-I has shown large effect sizes across

numerous studies.[64] While CBT-I is generally focused on insomnia complaints, sleep hygiene and education interventions have been disseminated widely to college students. These interventions have generally resulted in small to moderate improvements in sleep quality[64] and sleep knowledge.[63] In addition, when used as stand-alone interventions, relaxation and mindfulness generally lead to moderate sleep improvements.[64 66] Overall, sleep interventions in college students are associated with a full range of effect sizes, with increases in sleep duration and sleep efficiency and decreases in sleep onset latency and wake after sleep onset.[64]

Among collegiate athletes in particular evidence is more limited. Two studies prescribed increased sleep duration to small samples of basketball players[19] and tennis players.[20] One week[20] or 5–7 weeks[19] of sleep extension (ie, increasing daily sleep duration to >9–10 hours) were associated with significant increases in sleep duration, decreases in sleepiness and improvements in sport-specific performance indices (eg, tennis serve accuracy and sprint times, basketball shooting accuracy and faster reaction times). However, these studies did not include long-term follow-up, so the persistence of improvements is unknown. Two other studies reported on interventions focused on sleep hygiene and health for collegiate athletes. A 1-month sleep health intervention (delivered via pamphlet) improved self-reported sleep and improved perceived soccer performance among soccer players.[67] In addition, preliminary analyses of a pilot 10-week sleep health intervention indicated significantly better sleep, energy levels and collegiate athlete mental health.[68] Several studies have examined the effects of sleep interventions in trained athletes, primarily young adults.[69] Short-term (ranging from a single night to 1 week) sleep hygiene interventions have modestly improved sleep duration but not other sleep parameters or markers of athletic performance.[70–72] Improvement in perceived recovery was found in one study[71] but not another.[70] Biofeedback did not improve sleep quality in a sample of soccer and track athletes,[73] and progressive muscle relaxation led to minimal improvements in sleep among dancers.[74] Short-term (48 hours) or long-term (4 weeks) restrictions on use of late-night electronic devices did not improve sleep[75 76] or various markers of athletic and cognitive performance,[76] and five nights of sleep extension led to minimal improvements in measures of sleep or performance in adolescent pistol shooters.[77] In contrast, interventions involving comprehensive sleep education, feedback and tailored approaches to behaviour change over several weeks significantly improved sleep.[78 79] Finally, in a sample of golfers with sleep apnoea, treatment with continuous positive airway pressure therapy significantly improved sleep quality, decreased reported sleepiness and lowered golf handicaps.[80]

Although some collegiate athletics departments have modified their facilities or added programmes to improve sleep (eg, creation of napping rooms and comprehensive sleep monitoring systems), it remains unclear whether these strategies have improved collegiate athlete sleep. Overall, in addition to minimal research on non-pharmacological sleep interventions among collegiate athletes, the literature is greatly limited due to: small sample sizes, lack of control groups, insufficient sleep measures and minimal consideration for other relevant domains (eg, cognition, mental health, academic performance and sport performance).

Three per cent of NCAA collegiate athletes report non-prescription sleep aid use, while 18.7% of NCAA collegiate athletes report prescription sleep aid use.[81] However, there is a dearth of literature on pharmacological treatment of insomnia and other sleep disorders in collegiate athletes; furthermore, hypnotic medication use among college students is broadly discouraged

due to cognitive side effects and potential for adverse events when used with other drugs (eg, alcohol).[65] For these reasons, pharmacological recommendations as sleep aids were considered beyond the scope of the Interassociation Task Force on Sleep, and the reader is referred to the International Olympic Committee consensus statement on mental health in elite athletes for a detailed discussion of this matter.[82] Given the broad concerns of medication aids for sleep in collegiate athletes, insomnia-related complaints in this population should be managed behaviourally, since CBT-I produces similar short-term treatment outcomes and superior long-term treatment outcomes compared with pharmacotherapy.[83] Nevertheless, given the seemingly high prevalence of sedative-hypnotic use among collegiate athletes, more research on sleep medication use among collegiate athletes is needed to understand its sleep, health and performance-related implications.[84]

Consensus process

Based on the narrative review summarised above, the internal working group developed an initial list of 16 recommendations for collegiate athletics departments regarding collegiate athlete sleep (supplementary table 6). Following the first round of voting, there was consensus on the utility of all 16 recommendations (scores of ≥7); however, six did not achieve consensus regarding feasibility. Descriptive statistics for these 16 initial recommendations are included in supplementary table 5. Next, open-ended responses were reviewed for each recommendation, and key themes were identified. The most consistent theme related to feasibility was concern regarding lack of support for implementation. For example, an environmental assessment related to sleep barriers would be challenging without a readily available valid and reliable environmental assessment tool for institutions to use. Similarly, for on-campus implementation to occur, institutions would need a valid and reliable time demands survey (to assess quantitative and qualitative information on collegiate athlete commitments) and evidence-based educational/informational resources. A second emergent theme related to feasibility was how to provide institution-specific guidance when resources vary markedly across institutions (eg, personnel, funding and organisational structures). The internal working group reviewed these themes and revised the recommendations accordingly to improve feasibility. Implementation guidance for each recommendation was added, reviewed by the internal working group and content experts who contributed to the narrative review.

These revised recommendations and implementation guidance were returned to the panel for a second round of voting on utility and feasibility for the revised items. Open-ended feedback was elicited related to the implementation guidance for each recommendation, efficiently aggregating expert feedback about additional implementation resources and guidance accompanying each statement. All results of the second round of voting are provided in supplementary table 7.

There was consensus that each revised recommendation was useful (rounded scores of ≥7). However, only 5 of the 10 second round recommendations achieved consensus on their feasibility in college sports settings. The final set of five recommendations is provided in box 3 and include: (1) conducting an annual time demands survey, (2) incorporating sleep screening into the preparticipation exam, (3) providing evidence-based sleep education related to collegiate athletes and (4) coaches,and (5) ensuring that consumer sleep technology, if used, is compliant

with Health Insurance Portability and Accountability Act and Family Educational Rights and Privacy Act laws.

Box 3. Recommendations with consensus utility and feasibility

- Recommendation 1: Conduct a collegiate athlete time demands survey annually.
- Recommendation 2: Ensure that consumer sleep technology, if used, is compliant with HIPAA and FERPA laws.
- Recommendation 3: Incorporate sleep screening into the preparticipation exam.
- Recommendation 4: Provide collegiate athletes with evidence-based sleep education that includes: (1) information on sleep best practices; (2) information about the role of sleep in optimising athletic and academic performance and overall well-being; and (3) strategies for addressing sleep barriers.
- Recommendation 5: Provide coaches with evidence-based sleep education that includes: (1) information on sleep best practices; (2) information about the role of sleep in optimising athletic and academic performance and overall well-being; and (3) strategies to help optimise collegiate athlete sleep.
    - FERPA, Family Educational Rights and Privacy Act; HIPAA, Health Insurance Portability and Accountability Act.

Conclusion

Improving sleep in collegiate athletes has significant implications for health, athletic performance and academic achievement. However, athletes frequently fail to obtain restorative sleep. Factors related to their academic pursuits, training and competition can alter sleep patterns. Here we provide five recommendations related to collegiate athlete sleep that a panel of diverse experts considered useful and feasible for implementation in collegiate athletics departments. The Delphi process underscored the need for continued focus on developing and evaluating valid and reliable tools for sleep assessment and effective behavioural interventions among athletes and to support implementation of such tools and interventions in diverse sport environments. Such ongoing work can help contribute to the health and athletic performance of collegiate athletes and may have utility in other sport populations.

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Supplemental Table 1.
Interassociation Task Force on Sleep and Wellness

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Supplemental Table 2.
NCAA GOALS Study: Hours of Sleep on a Typical Weekday, by NCAA Division

	Division I			Division II			Division III		
	Men	**Women**	**Combined**	**Men**	**Women**	**Combined**	**Men**	**Women**	**Combined**
≤4 Hours	13.5%	8.2%	10.9%	16.0%	9.7%	13.3%	10.6%	7.8%	9.4%
5 Hours	11.1%	14.6%	12.8%	11.3%	12.3%	11.8%	10.8%	12.9%	11.7%
6 Hours	24.5%	28.3%	26.3%	23.4%	28.6%	25.7%	26.4%	28.8%	27.4%
7 Hours	28.1%	28.3%	28.2%	25.8%	28.7%	27.1%	30.6%	31.0%	30.8%
≥8 Hours	22.9%	20.6%	21.8%	23.4%	20.7%	22.2%	21.6%	19.5%	20.7%

Supplemental Table 3.
NCAA GOALS Study: Prevalence of Difficulty Sleeping for ≥8 of the Past 30 Days among Collegiate Athletes

	Division I	**Division II**	**Division III**
Men's Baseball	16%	17%	15%
Men's Basketball	24%	17%	20%
Men's Football	27% (FBS) / 25% (FCS)	21%	22%
Men's Other Sports	19%	19%	16%
Women's Basketball	25%	22%	22%
Women's Other Sports	25%	23%	20%

FBS = Football Bowl Subdivision; FCS = Football Championship Subdivision.

Table 5.
Instruments for Measuring and Tracking Athletes' Sleep

Instrument	Captured Measures	Primary Utility	Supportive Evidence*	Limitations
Sleep Diary[89]	Time into bed, sleep latency, awakenings, awakening duration, time awake; sleep timing, duration, and efficiency; other factors such as subjective ratings, napping, and disturbances	Assessment of sleep timing, duration, consistency, and disruption over days/weeks	+++++	Inconsistent completion, recall bias
Pittsburgh Sleep Quality Index[46]	7 component scores (sleep quality, latency, duration, efficiency, disturbance, use of sleeping medications, and daytime dysfunction) and one composite score of overall sleep quality	Assessment of sleep quality over 1 month	+++++	Can broadly discriminate good from poor sleepers, but does not elucidate causes of poor sleep
Epworth Sleepiness Scale[52]	8-item scale that provides a composite score of sleepiness over the past month	Helpful in screening subjects with potential sleep disorders	+++++	Measures "chance of dozing" in certain situations. Will not capture sleepiness in subjects not prone to unplanned sleep
Insomnia Severity Index[48]	7 items that provide a composite score of sleep difficulty	Aids in diagnosis of insomnia and tracking response to treatment over time	+++++	Causes of insomnia not ascertained
Fatigue Severity Scale[90]	9-item scale that measures the impact of fatigue on a person's ability to function	High score indicates evaluation by a physician is necessary to determine cause	+++++	Causes of fatigue not ascertained; susceptible to recall bias
Polysomnography[44]	EEG, EOG, chin and leg EMG, nasal pressure transducer, oral thermistor, chest and abdominal effort, oxygen saturation, body position, snoring microphone, EKG	Diagnosis of sleep disorders such as sleep apnea; some utility for other disorders such as parasomnias and PLMD; necessary to perform the night before a Multiple Sleep Latency Test.	+++++	Tests sleep in laboratory environment for one night. May not be representative of nightly sleep in the subject's typical environment
Multiple Sleep Latency Test[57]	Frontal, central, and occipital EEG, left and right EOG,	Diagnosis of central nervous system hypersomnias such	+++++	Tests ability to fall asleep, not stay awake, which

	and mental and submental EMG, snoring microphone, and EKG	as narcolepsy and idiopathic hypersomnia		may be more meaningful to quality of life and functioning
Maintenance of Wakefulness Test[45]	Frontal, central and occipital EEG, left and right EOG, mental and submental EMG, snoring microphone, and EKG	Used to assess treatment effect on various sleep disorders	+++++	Normative values not well established
STOP-BANG Questionnaire[91]	8 items that provide a composite score of sleep apnea risk	Identifies individuals who would benefit from a sleep medicine evaluation for sleep apnea	++++	Low specificity yields a high false-positive rate; some items not as relevant for athletes (e.g., high blood pressure and obesity)
Karolinska Sleepiness Scale[51]	Single-item real-time subjective sleepiness assessment	Tracks sleepiness/ alertness over a day. Measures effectiveness of an intervention or treatment over time	++++	Causes of sleepiness not ascertained; state measure; situation-dependent
Stanford Sleepiness Scale[50]	Single-item assessing current level of sleepiness	Tracks sleepiness/alertness over the course of a day. Measures effectiveness of an intervention or treatment over time	++++	Causes of sleepiness not ascertained; state measure; situation-dependent
Actigraphy[59]	Wrist/arm/body movement via accelerometry	Measures sleep latency, duration, fragmentation and efficiency	++++	Does not directly measure sleep; can overestimate sleep relative to polysom-nography. Specific devices should be independently validated.
Recovery-Stress Questionnaire for Athletes[55]	7 stress and 5 recovery scales (Likert-type, 0=never; 6=always) with a time frame of 3 or 7 days/nights	Measures frequency of current stress symptoms (general, emotional social, conflicts/pressure, fatigue, lack of energy, physical complaints) and recovery-associated activities (success, social recovery, physical recovery,	+++	Source of stress not identified

		sleep quality, general well-being)		
Home Sleep Apnea Test[92]	Many different devices. Some (e.g., Embletta®) measure nasal and oral airflow, pulse oximetry and chest and abdominal respiratory effort; others (e.g., Watch-PAT) measure pulse oximetry and peripheral arterial tone at the wrist. Watch-PAT also assesses sleep stages	Diagnosis of sleep apnea in the person's typical sleeping environment	+++	Not sensitive enough to rule out sleep apnea; negative studies need to be confirmed with polysomnography
Leeds Sleep Evaluation Questionnaire[47]	10 self-rating questions that evaluate ease of initiating sleep, quality of sleep, ease of waking, and behavior following wakefulness	Designed to assess changes in sleep quality during a psychopharma-cologic treatment intervention	+++	No assessment of historic sleep issues
SleepScore Max[93]	Device is placed at the bedside and uses radiofrequency emissions to monitor body movement (including chest and abdominal respiratory movement) during sleep. Generates a nightly sleep score from 0-100, higher scores indicate better sleep	Allows consumers to monitor their sleep in a contactless manner each night in their typical sleeping environments	++	Overestimated light sleep and REM sleep by 12 minutes per night, under-estimated deep sleep by 10 minutes per night in a study of n=22 [96]
Fitbit Sleep Stages[94]	Device is worn around the wrist and uses an accelerometer and optical photoplethsymogram to assess body movement, breathing, and heart rate variability to determine sleep/wake and sleep stages	Allows consumers to monitor their sleep in a contacted manner on a nightly basis in their typical sleep environments	+	Accuracy* as follows: Light Sleep (69.2%), Deep Sleep (62.4%), REM Sleep (71.6%). Wake Specificity[#] (69.3%)
SleepScore App	Turns mobile phone into an active sonar to monitor body	Allows consumers to monitor their sleep in a	+	Accuracy* as follows: Wake (84%), Light

	movement (including chest and abdominal respiratory movement) during sleep. Generates a nightly sleep score from 0-100, higher scores indicate better sleep. No additional device necessary.	contactless manner each night in their typical sleeping environments without need for an additional device beyond their mobile phone.		Sleep (64%), Deep Sleep (83%), REM Sleep (89%)[97]

Supportive evidence ranked on a scale of + to +++++ with higher rankings indicating more and higher-quality evidence.
EEG=electroencephalogram; EOG=electrooculogram; EMG=electromyogram; EKG=electrocardiogram; PLMD= periodic limb movement disorder; Light Sleep= Stages N1 and N2, Deep Sleep=Stage N3, Epoch= a 30 second period of time. *Accuracy is defined as the percentage of epochs correctly labeled relative to the gold standard, [#]Wake specificity is defined as the percentage of true wake epochs correctly labeled as wake.

Supplemental Table 6.
Summary of utility and feasibility scores for 16 first-round recommendations

Recommendation	Utility				Feasibility			
	Mean	SD	Median	Range	Mean	SD	Median	Range
Recommendation 1: Identify a multidisciplinary team to oversee all work related to measuring and improving collegiate athlete sleep.	7.96	1.02	8	5 to 9	5.75	1.48	6	2 to 8
Recommendation 2: Schedule practice to allow for athletes to regularly maintain adequate sleep.	8.00	1.53	9	4 to 9	5.80	2.14	6	2 to 9
Recommendation 3: Minimize changes to practice schedules to allow for athletes to maintain a consistent sleep schedule.	7.72	1.49	8	3 to 9	6.00	1.66	6	3 to 8
Recommendation 4: Conduct a campus-wide environmental assessment to determine barriers to collegiate athlete sleep on their campus.	7.40	1.71	8	3 to 9	6.44	2.42	7	2 to 9
Recommendation 5: Conduct a collegiate athlete time demands survey annually to provide their institution with aggregate measures of sleep opportunity.	7.40	1.26	8	5 to 9	6.84	1.75	7	3 to 9
Recommendation 6: Direct the multidisciplinary sleep team to review the results of the time demands survey annually and identify areas for improvement or intervention.	7.28	1.24	7	5 to 9	6.64	1.85	6	3 to 9
Recommendation 7: Provide all athletics stakeholders (including but not limited to collegiate athletes, coaches, administrators, and sports medicine staff) with the results of the time demands survey annually.	8.20	0.96	9	6 to 9	7.80	1.32	8	5 to 9
Recommendation 8: Provide collegiate athletes with a standardized tool to assess their sleep habits.	8.16	0.99	8	5 to 9	7.28	1.51	8	3 to 9
Recommendation 9: Provide collegiate athletes with a standardized tool to assess their sleep environment.	8.12	1.13	8	5 to 9	7.32	1.75	8	2 to 9
Recommendation 10: Understand the extent to which sleep-tracking technology, if used, has been validated scientifically, and communicate this to collegiate athletes and athletics administrators.	7.16	2.10	8	1 to 9	6.25	1.98	7	2 to 9
Recommendation 11: Ensure that sleep-tracking technology, if used, is compliant with HIPAA and FERPA laws.	7.70	1.89	9	2 to 9	7.25	1.98	8	3 to 9
Recommendation 12: Incorporate sleep screening into the pre-participation exam.	8.56	0.92	9	5 to 9	7.72	1.65	8	2 to 9
Recommendation 13: Establish a protocol for sleep screening follow-up, including specific follow-up steps for referrals to (campus and/or off-campus) medical providers.	8.52	0.92	9	7 to 9	6.92	1.98	7	5 to 9

Recommendation 14: Provide collegiate athletes and coaches with information about sleep best practices.	8.36	1.38	9	3 to 9	8.32	1.25	9	5 to 9
Recommendation 15: Provide consensus- and evidence-based sleep education to collegiate athletes and coaches.	8.52	0.92	9	5 to 9	7.96	1.70	9	3 to 9
Recommendation 16: Direct the multi-disciplinary sleep team to develop an annual process for evaluating the acceptability, implementation and impact of sleep-related educational interventions.	7.36	1.15	8	5 to 9	6.24	1.59	6	4 to 9

Supplemental Table 7.
Summary of utility and feasibility scores for 10 second-round recommendations

Recommendation	Utility				Feasibility			
	Mean	SD	Median	Range	Mean	SD	Median	Range
Recommendation 1: Identify a team to oversee all work related to measuring and improving collegiate athlete sleep. **Implementation guidance:** • Select a multidisciplinary team, taking into consideration the sleep-related expertise of team members. • Establish an annual process for reviewing initiatives related to sleep for acceptability and utility.	7.62	1.32	8	5 to 9	5.90	2.24	6	1 to 9
Recommendation 2: Schedule practices to allow for athletes to regularly maintain adequate sleep. **Implementation guidance:** • Work with athletes and coaches to determine whether early morning practices allow for adequate sleep. • Encourage coaches to consider tradeoffs between increased practice time and more efficient and effective use of time made possible by having well-rested collegiate athletes.	8.10	1.09	8	4 to 9	5.60	1.61	5.5	3 to 9
Recommendation 3: Minimize variability in practice schedules to allow athletes to maintain a consistent and healthy sleep schedule. **Implementation guidance:** • Work with athletes and coaches to determine how far in advance they would like to have their practice schedule set to allow for consistent sleep. • Encourage coaches to minimize disruptions in practice schedules.	7.90	1.21	8	5 to 9	6.27	1.64	6	3 to 9
Recommendation 4: Conduct an environmental assessment to determine barriers to collegiate athlete sleep. **Implementation guidance:** • Consider using consumer sleep technology to assess bedroom temperature, light, and noise levels. • Consider having a sleep expert assess and optimize the collegiate athlete sleep environment. • Consider surveying the students'	7.60	1.33	8	3 to 9	6.30	2.23	6	2 to 9

experience of environmental barriers to sleep.								
Recommendation 5: Conduct a collegiate athlete time demands survey annually. **Implementation guidance:** • Consider using the following resource: NCAA GOALS time use survey questions (questions 69-73: http://www.ncaa.org/sites/default/files/Instrument_0.pdf) • Review the results of the time demands survey annually and identify areas for improvement or intervention. • Provide all athletics stakeholders with the results of the time demands survey annually.	7.59	1.35	8	4 to 9	7.41	1.62	8	4 to 9
Recommendation 6: Determine whether consumer sleep technology, if used, has been scientifically validated. **Implementation guidance:** • As science related to consumer sleep technology continues to evolve, establish a process for reviewing updates related to technology validation with a faculty member with relevant expertise. • Ensure that information about validated consumer sleep technology is communicated to athletics stakeholders on an annual basis.	6.59	1.88	7	3 to 9	6.14	2.03	6	2 to 9
Recommendation 7: Ensure that consumer sleep technology, if used, is compliant with HIPAA and FERPA laws. **Implementation guidance:** • In consultation with a campus expert in student privacy, contact consumer sleep technology manufacturers to determine HIPAA and FERPA compliance.	6.79	2.13	7	1 to 9	7.00	1.98	7	2 to 9
Recommendation 8: Incorporate sleep screening into the pre-participation exam. **Implementation guidance:** • Use sleep screening that assesses total sleep duration, sleep schedule timing and regularity, sleep latency, sleepiness, sleep quality and sleep satisfaction. Assessing additional factors that disrupt sleep can help support staff to direct collegiate athletes to appropriate resources. The Athlete Sleep Screening Questionnaire	8.17	1.00	8	5 to 9	6.97	1.80	8	3 to 9

(Bender et al., 2018) and Athlete Sleep Behavior Questionnaire (Driller et al., 2018) have been validated for use with athletes. • Considering repeating or conducting the sleep screening process mid-season. • Establish a protocol for sleep screening follow-up, including triggers for referral to (campus and/or off-campus) sleep medicine providers.								
Recommendation 9: Provide evidence-based sleep education to collegiate athletes that includes: 1) information on sleep best practices; 2) information about the role of sleep in optimizing athletic and academic performance and overall wellbeing; and 3) strategies for addressing sleep barriers. **Implementation guidance:** • Provide information about sleep resources on campus, including whom the collegiate athlete should contact with concerns about sleep. • Consider sharing information from the following resources with your athletes: NCAA Mind, Body and Sport: http://www.ncaa.org/sport-science-institute/mind-body-and-sport-sleeping-disorders American Academy of Sleep Medicine: www.sleepeducation.org	8.39	0.88	9	6 to 9	8.04	1.17	8	5 to 9
Recommendation 10: Provide evidence-based sleep education to coaches that includes: 1) information on sleep best practices; 2) information about the role of sleep in optimizing athletic and academic performance and overall wellbeing; and 3) strategies for coaches to help optimize collegiate athlete sleep. **Implementation guidance:** • Consider sharing information from the following resources with your coaches: NCAA Mind, Body and Sport: http://www.ncaa.org/sport-science-institute/mind-body-and-sport-sleeping-disorders American Academy of Sleep Medicine: www.sleepeducation.org	8.43	0.74	9	7 to 9	8.04	1.35	9	5 to 9