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PII: S1060-1872(22)00009-0
DOI: <https://doi.org/10.1016/j.otsm.2022.150897>
Reference: YOTSM 150897

To appear in: *Operative Techniques in Sports Medicine*

Please cite this article as: Meeta Singh , Stephen P. Bird , Jonathan Charest , Michael Workings ,
SLEEP AND ATHLETES, *Operative Techniques in Sports Medicine* (2022), doi:
<https://doi.org/10.1016/j.otsm.2022.150897>

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SLEEP AND ATHLETES

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ABSTRACT

Sleep is recognized as an essential component to optimize health and human performance, and as such

the topic is of increasing interest to athletes. Yet, the sleep of athletes is affected by multiple sports-

specific and societal factors. Hence the recent emergence of the important role of sleep science in

athlete health and performance. This review focuses on the fundamentals of sleep physiology and

elaborates on the affects sleep has on athlete health and performance. Despite sports practitioners

recognizing the importance of sleep on health and performance, findings report that insufficient sleep

and poor sleep quality are prevalent among athletic populations. This paper will describe sleep in

athletes, define sleep characteristics, discuss the impact of sleep restriction following travel and

competition, and strategies to mitigate sleep difficulties. Sleep is arguably the most undervalued pillar

of health and performance.

Keywords

Sleep; Athlete; Health; Performance

1. SLEEP AND ATHLETES: A BRIEF OVERVIEW

I. Introduction

Sleep is recognized as an essential component to optimize health and human performance, and as such the topic is of increasing interest to athletes. Recent literature points to the profound effect that sleep has, not only on promoting recovery and athletic performance,^{1, 2} but also on almost every aspect of psychosocial and physiological health.³ Sleep is the only naturally occurring component of human life that exerts influences on these psychosocial-physiological phenomena. Recent works from the field of neuroscience suggest this may be linked to the neuroprotective benefits of sleep – a cascade of neurobiological events that drive a homeostatic mechanism for metabolite clearance of neurotoxins from the brain.⁴⁻⁶ Human beings spend one third of their lives sleeping.⁷ According to the American Academy of Sleep Medicine,⁸ the recommended amount of sleep to achieve optimal health will vary across a lifespan and gradually decrease from birth to older adulthood with adults requiring between 7 to 9 hours of sleep for optimal health and adolescents needing 8 to 10 hours of sleep. It has been suggested that athletes may require greater amount of sleep (9-10 hours) to recover from injuries, intense training periods and competition and this may involve a sleep extension approach (see section 3) to promote longer sleep opportunity than normal.⁹ This is an important consideration as research suggests that athletes don't get the required amounts of sleep and their sleep quality is often suboptimal.^{10, 11} Additionally, athletes often sleep poorly despite adequate opportunity to do so both prior to and immediately after competition.^{10, 12, 13} Thus, educating sports medicine physicians and sports training staff as well as performance staff about sleep and its benefits becomes of paramount importance.¹⁴ The aim of this overview is to provide basic knowledge about sleep and its importance to athlete health and performance with additional practical strategies that they may use in their practice with athletes.

2. SLEEP SCIENCE: A PHYSIOLOGICAL BASIS

a. The definition of sleep

Sleep is a normal reversible behavioral state of perceptual disengagement from and unresponsiveness to the environment.¹⁵ Although one looks passive and very restful, it is also true that sleep is a complex amalgam of physiologic and behavioral processes during which key physiological, neural and psychological recovery processes take place. Sleep is typically accompanied by postural recumbence, behavioral quiescence, closed eyes, and all the other indicators one commonly associates with sleeping.

b. Sleep cycle and key sleep stages

Within sleep, the brain is quite active and thus two separate sleep states have been defined based on a constellation of physiologic parameters. These two states, rapid eye movement (REM) and non-REM (NREM), exist in virtually all mammals and birds yet studied, and they are as distinct from one another as indeed distinct from the state of wakefulness. NREM is conventionally subdivided into 3 stages defined along one measurement axis, the electroencephalogram (EEG). During NREM sleep, the brain is relatively inactive while the body is movable. The EEG pattern in NREM sleep is commonly described as synchronous, with such characteristic waveforms as sleep spindles, K-complexes, and high voltage slow waves. The three NREM stages (stages N1, N2 and N3) roughly parallel a depth-of sleep continuum, and its easiest to be awakened from stage N1, while N3, is the deepest stage of sleep.¹⁶ REM sleep, by contrast, is defined by EEG activation, muscle atonia, and episodic bursts of rapid eye movements. Thus, in contrast to NREM sleep, REM sleep is characterized by a brain that is relatively active in a body that is immobile. This is also the stage that is associated with dream activity.¹⁷ The human brain enters sleep via NREM (stage N1) and progresses through deeper NREM stages (stages N2 and N3) before the first episode of REM sleep occurs approximately 80–100 minutes later.¹⁸ Thereafter, NREM sleep and REM sleep cycle with a period of approximately 90 minutes. Slow wave sleep (stage N3) is concentrated

in the early NREM cycles, and REM sleep episodes are longest in the last one third of the night. Brief episodes of wakefulness tend to intrude later in the night, usually near REM sleep transitions, and they usually do not last long enough to be remembered in the morning. This progression of sleep stages is shown in Figure 1.

c. The regulation of sleep

Two internal biological mechanisms—homeostasis and circadian rhythm—work together to regulate when you are awake and sleep.²⁰ The homeostatic process keeps track of your need for sleep. This sleep drive gets stronger every hour you are awake and causes you to sleep longer and more deeply after a period of sleep deprivation. Circadian rhythms direct a wide variety of functions from daily fluctuations in wakefulness to body temperature, metabolism, and the release of hormones. They control your timing of sleep and cause you to be sleepy at night and your tendency to wake in the morning without an alarm. In fact, our relatively steady state of alertness over the course of a 16-hour day is due to the circadian alerting system. Thus, under normal conditions, the clock is highly synchronized to our sleep/wake cycle. The clock's alerting signal increases with every hour of wakefulness, opposing the sleep drive that is building at the same time. Only when the internal clock's alerting signal drops off does sleep load overcome this opposing force and allow for the onset of sleep (Figure 2).

d. Measuring Sleep

Tools to measure sleep can be divided into several primary categories which include; polysomnography, activity monitoring (including research grade and consumer wearables), wearable devices and smartphone applications, sleep diaries, and questionnaires.⁹ Although a comprehensive review of sleep measuring devices is outside the scope of this review article it is essential to be aware that despite the increasing options that are available there are some limitations including, validation.

Thus, a careful assessment as to what question about sleep needs to be answered and what tool would be most appropriate and useful should be made every time measurement of sleep is considered.

3. SLEEP TO PERFORM

An athlete's ability to perform at a high level is determined by several factors, with sleep perceived as the most important for recovery by elite athletes.²² Recently, there is emerging awareness among athletes, coaches, and trainers about the importance of sleep science in the design of sleep interventions to improve not only recovery, but health and performance.^{14, 23} However, significant sleep disturbances, including insufficient sleep and poor sleep quality, are still highly prevalent among athletes.²⁴ This may be due – in part, to sport-related time demands, chronotype, and lack of sleep-related education. The authors highlight that such sleep disturbances present potential deleterious impacts on health and daytime sleepiness, and adverse effects on physical and mental performance, recovery status, injury risk and, more importantly, concussion.²⁴ In agreement, recently we described the detrimental effects of poor sleep on the health and performance in National Basketball Association (NBA) players,¹⁴ noting parallel problems in the National Hockey League (NHL).²⁵ Collectively, athletes recognize the importance of 'sleep to perform', however barriers remain resulting in ongoing sleep disturbances. As physicians, coaches, and support staff, we must seek new opportunities to educate athletes and implement sleep screening and education strategies that have long-term implications for health and athletic performance (Figure 3).

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4. HOW SLEEP AFFECTS ATHLETES' PERFORMANCE

a. Sleep and travel

The multifaceted demands of elite sport have made air travel across several time zones a ubiquitous reality of elite athletes. Jet lag associated with transmeridian flights can potentially cause deleterious effect that can occur and last several days after arrival and may predispose athletes to sleep disturbance and daytime dysfunction. Thus, athletes can be faced with circadian disruptions which is

refer to as jet lag²⁷ and they can also face travel fatigue.²⁸ Symptoms of jet lag are typically represented by a combination of fatigue, sleepiness, gastrointestinal disturbance, impaired concentration and disorientation that occurs in the days following arrival to a new time zone.²⁷ In contrast, travel fatigue may occur while flying within the same time zone and immediately after arrival to destination. Symptoms of travel fatigue may include fatigue, lower motivation, and headache²⁹ that can be caused by sleep loss, cabin discomfort, dehydration, restricted space, poor quality food, sleep loss and several other detrimental realities of long flight.²⁸

The desynchronization of the circadian system to new environment requires time to adjust.³⁰ Therefore, the repeated travel across time zones for the length of an 82-matches season in the NBA and the NHL^{14, 25} and 162-matches season in the Major League Baseball (MLB) will inevitably cause a chronic desynchronization of the circadian system in athletes. In addition to this chronic desynchronization, travel fatigue will parallelly accumulate throughout the season. Hence, the deleterious impact of travel fatigue and circadian disruption represents a challenge that will lead athlete into sleep restriction, deprivation and inadequacies that will ultimately impair their performance and mental health.^{9, 24} Given that cognitive performance is sensitive to sleep restriction, traveling may predispose athlete and act as a precipitating factor into cognitive impairment.³¹

b. Sleep, Competition and Performance

Sleep represents the best natural enhancer for recovery.²³ Deleterious impact of sleep restriction on athletic performance have been documented for several years, including key performance characteristics such as aerobic and anaerobic capacity, strength and speed, and psychomotor effect.^{9, 24} However, sleep optimization interventions have only begun to surface, although some results are mitigated, other interventions are promising. Interventions such as bright-light exposure,³² cold water immersion,^{33, 34} and nutritional intervention,^{35, 36} may improve sleep short term but have yet to be proven efficient on long term. Conversely, sleep extension such as extending the nocturnal total sleep

time and total daily time by adding naps have demonstrated interesting outcomes. A very well-known study conducted by Mah and colleagues,³⁷ with eleven basketball collegiate athletes showed that sleep extension not only improved mood but significantly enhanced sport specific features such as free throw and 3-points throw.

In addition, in 12 tennis collegiate athletes, a one-week sleep extension resulted in an improved service accuracy of approximately 6% and a decreased sleepiness.³⁸ Both these studies showed sport specific improvements, but their sample size remain small and only 5 females were included within these 2 studies. Additionally, neither of these studies included a long term follow up, therefore the persistence of improvement remains unknown. Moreover, napping presents an ecological strategy to supplement athletes' night-time sleep without impeding their following night. Throughout research, not only does nap reduces sleepiness while increasing alertness but also confers several advantages including enhanced physical and cognitive performance and perceptual state such as exhaustion and fatigue. Regardless of the sleep debt a participant may accumulate, various studies demonstrated positive outcomes of napping on cognitive performance.³⁹⁻⁴¹ Although naps present benefits to athlete, they are not created equal as they differ in length (e.g., 20 min vs 90 min). A 90-minute nap compared to a 20-minute nap showed greater positive influence on cognitive effects with a digit-cancellation task.⁴⁰ According to a systematic review on athlete and napping behaviors, athlete should dedicate between 20 and 90 min for napping and target a specific timing between 13:00 and 16:00.⁴²

5. CONCLUSIONS AND FUTURE DIRECTIONS

Promotion of sleep as a cornerstone for health and performance in athletes remains an uphill challenge. For many years, sleep has been pictured as a disposable variable that could be dealt with later. Even worse, lack of sleep has long been promoted in society as "*sleep machismo*",⁴³ a badge of honor and mental strength. To reverse and counter this sleep restricted society culture, we must educate coaches and athletes that sleep deprivation is not a badge of honor and promote a culture of

healthy sleep as an athletic and general wellbeing enhancer. Embracing the concept of sleep as a *'pillar of performance'*, both on and off the field, instead of an expandable variable would help restructure the concept of sleep. Simultaneously, encouraging athletes to prioritize napping daily could invalidate the feeling of guilt that athletes may feel while sleeping during the day. Providing teams with accessible information on sleep health including sleep education sessions would raise awareness of the importance of adequate sleep. Screening systematically athletes for sleep problems to identify those who struggle with primary sleep disorder such as insomnia, sleep apnea, restless legs, etc. When sleep disorders are identified, appropriate evidence-based treatments should be applied by a certified sleep specialist. Therefore, teams and support teams should be educated on diagnosing and treating sleep disorder and have the resource at hand to refer to the appropriate care provider. Some high-profile athletes have acted lately as standard-bearer regarding sleep; however, they do not yet represent the norm. Although a slow change in sleep culture may be emerging among athletes, sleep remains far down the list of priorities. Education and resources accessibilities may enable a change in the sleep culture paradigm.

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Conflict of Interest Statement

No conflict

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Figure 1. A hypnogram showing normal distribution of sleep stages.¹⁹

Figure 2: The two-process model of sleep regulation.²¹

Figure 3. Proposed relationships between poor sleep health and impaired athletic performance.^{24, 26}