

# Sleep Optimization in the Young Athlete

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## Abstract:

Young athletes commonly suffer from both acute and chronic sleep deprivation. This has been linked to increased injury rates and decreased athletic and neurocognitive performance. Conversely, sleep optimization in young athletes can lead to improved athletic performance and greater competitive success, with improvement in metrics such as speed, endurance, reaction time, accuracy, alertness, and overall well-being. When aiming to optimize sleep, key elements such as sleep duration, quality, and regularity must be addressed. Clinicians can assess baseline sleep hygiene in young athletes and educate them on proper methods to optimize sleep. Such methods include limiting screen time before bed, getting exposure to sunlight in the early morning, maintaining an optimal bedroom temperature, avoiding caffeine, and maintaining a consistent sleep schedule throughout the week.

## Key Concepts:

- Chronic sleep deprivation, defined as five consecutive nights of restricted sleep (<8 hours), is associated with increased injury risk in young athletes.
- Insufficient sleep is detrimental to athletic performance and has been found to negatively affect metrics such as speed, endurance, reaction time, accuracy, and alertness.
- Conversely, optimization of sleep in young athletes has been found to improve athletic performance as well as subjective physical and mental well-being.
- Methods to optimize sleep in young athletes include limiting screen time before bed, getting exposure to sunlight in the early morning, maintaining an optimal bedroom temperature, avoiding caffeine, and maintaining a consistent sleep schedule.

## Introduction

In the United States, it has been reported that between 50% and 75% of middle school and high school-aged children do not get an adequate amount of sleep.<sup>1</sup> According to the American Academy of Sleep Medicine, children ages 6–12 years require 10–12 hours of sleep daily and teenagers (13–18 years) require 8–10 hours daily.<sup>2</sup> Sleep deprivation is categorized either as acute—the loss of one night of adequate sleep or chronic—five consecutive nights of restricted sleep.<sup>3,4</sup> Inadequate

sleep, either acutely or chronically, may lead to neurocognitive impairment, which can be detrimental to learning, memory capacity, and school performance.<sup>5</sup> In the context of athletics specifically, acute and chronic sleep loss can lead to increased risk of injury as well as decreased athletic performance.<sup>6,7</sup> Conversely, sleep optimization in the young athlete can lead to improved athletic performance and greater on-field success. The purpose of this current concept review is to provide an over-

view of the literature exploring the relationship between sleep and athletic performance, specifically focusing on the benefits of sleep optimization in the young athlete.

## Sleep and Injury

### *Chronic Sleep Deprivation*

Similar to the general population, it has been found that youth athletes commonly suffer from chronic lack of sleep, with some studies showing rates as high as 77%.<sup>6,8</sup> It has been well established in the literature that chronic sleep deprivation is associated with increased risk of injury in young athletes. A meta-analysis by Gao et al. explored the relationship between lack of sleep and sports injuries in adolescents and found that adolescents who were chronically sleep deprived were at a significantly increased likelihood of experiencing a sports or musculoskeletal injury. This meta-analysis encompassed five large scale studies, all of which supported a relationship between chronic sleep deprivation and increased injury rates.<sup>9</sup>

### *Acute Sleep Deprivation*

Many studies have demonstrated a high prevalence of acute sleep deprivation among athletes prior to competition, with rates reported as high as 78%.<sup>8,10,11</sup> Increased stress and anxiety leading up to competition have been thought to reduce sleep quality and duration. While the relationship between chronic sleep deprivation and injury is well-defined, the evidence is less conclusive for acute sleep deprivation. The meta-analysis by Gao et al. included two studies that explored acute sleep deprivation and injury rates in adolescent athletes which yielded conflicting results.<sup>9</sup> One study found no difference in sleep volume the night preceding an injury,<sup>12</sup> while a separate study found that sleeping  $\leq 6$  hours was associated with fatigue-related injuries the following day.<sup>13</sup> Of note, a recent study by Watson et al. evaluated acute sleep deprivation in male collegiate basketball players, finding that a 1-hour decrease in sleep duration was associated with a 43% increase in injury risk the following day.<sup>14</sup> This is an area of interest that would benefit from additional research.

## Sleep and Performance

### *Sleep Deprivation and Athletic Performance*

Insufficient sleep has a negative impact on general athletic performance, with poor sleep quality and duration correlated with decreased competition success.<sup>15,16</sup> Athletic performance can even be differentially affected based on the severity of sleep loss. Acute sleep deprivation, categorized as the loss of one night of adequate sleep,<sup>3,4</sup> has a significant detrimental effect on aerobic performance. Studies testing athletes in their twenties from a variety of sports found that those in an acutely sleep-deprived state showed decreased times to exhaustion, decreased speed and distance covered in a set time, and slowed reaction times compared to their normal sleep counterparts.<sup>17-19</sup>

Athletes' recovery after intense training may also be negatively impacted by acute sleep deprivation as measured by their performance in repeated physical tasks. Cyclists<sup>20,21</sup> and sprinters<sup>22</sup> recorded their baseline performance in a variety of measures (time trials, power output, sprint times) and then performed high-intensity training regimens, followed by normal or acutely restricted sleep. Upon repeated performance of the baseline measures, the acute sleep deprivation groups demonstrated worse performance (e.g., slower time trials, decreased peak power output, slower sprint times) than the control groups.<sup>20-22</sup> These studies provide evidence to support the crucial role that sleep plays in recovery.

Acute loss of sleep can also lead to decreases in athletic accuracy as demonstrated in studies evaluating tennis serves<sup>23</sup> and dart throwing,<sup>24</sup> illustrating the negative effects of acute sleep deprivation on coordinated fine and gross motor control in addition to cardiovascular and aerobic function.

The impact of acute sleep deprivation on anaerobic performance remains inconclusive. A study by Reilly et al. found that acute sleep restriction caused decreased performance in a series of anaerobic exercises such as bench press, deadlift, and leg press in comparison to

baseline metrics.<sup>25</sup> However, it should be noted that athletes in this study were sleep restricted for three consecutive nights, and significant changes were only noted following the second night. Studies evaluating anaerobic performance following one single night of sleep deprivation have shown that acute sleep loss yielded no difference in power output or weightlifting performance.<sup>26,27</sup> It may be that acute sleep loss can become detrimental to anaerobic performance following multiple consecutive nights of restricted sleep.

Chronic sleep deprivation, categorized as five consecutive nights of inadequate sleep,<sup>3,4</sup> has been shown to cause increased fatigue, stress, and soreness as well as decreased mood in youth athletes.<sup>28</sup> Chronic sleep impairment may also have potentially longer lasting effects on athletic performance. Belenky et al. demonstrated that volunteers with seven consecutive days of 3, 5, or 7 hours of sleep had progressively decreased performance on psychomotor vigilance tasks (sustained-attention, reaction-timed tasks that measure speed of response to visual stimuli) over the course of the week compared to a control group that obtained 9 hours of sleep. More significantly, however, were the results from repetition of the tasks after a recovery period of three consecutive nights of adequate sleep. It was found that performance among all sleep deprived groups remained decreased, suggesting that a full recovery to baseline may require a significant amount of time to occur.<sup>3</sup> The authors noted that the brain may undergo adaptive changes in the setting of chronic sleep deprivation that allow for function at a stable, yet reduced, level of performance. These changes may persist into the recovery period, causing a slow de-adaptation following restoration of adequate sleep.<sup>3</sup> Further research is needed to explore the time frame for recovery from chronic sleep deprivation.

#### *Impaired Sleep and Neurocognitive Function*

Loss of sleep has also been shown to negatively impact neurocognitive aspects of young athletes' performance. A study by Pallesen et al. showed that acutely sleep deprived junior soccer players (average age 16 years) performed worse on tasks that required continuous attention

and improved at a slower rate on novel tasks compared to a control-sleep group.<sup>29</sup> Additional studies have reported similar results, demonstrating worsened attention, learning capacity, and cognitive processing speed in acutely sleep-deprived subjects.<sup>30</sup> In these ways, the studies showed that insufficient sleep may decrease athletes' concentration and ability to learn new skills or techniques. It has also been demonstrated that acute sleep loss can decrease positive affect and increase risk taking in inhibitory control tasks.<sup>31</sup> These behavioral changes can alter on-field decision-making and overall well-being of the athlete.

## **Optimization of Sleep**

### *Benefits of Improved Sleep*

While poor sleep is detrimental to athletic performance; conversely, optimization of sleep in young athletes can lead to improved performance and greater on-field success. Numerous studies have demonstrated that improving sleep quality and duration can lead to improved speed, accuracy, reaction time, endurance, and overall physical and mental well-being in collegiate athletes.<sup>32-35</sup>

A study of Division I collegiate basketball players by Mah et al. demonstrated that following a sleep extension period of 10 hours per night for 5–7 weeks, athletes experienced improved free-throw percentage, faster timed sprints, decreased reaction time, and improved ratings of physical and mental well-being during training and competition.<sup>33</sup> Mah et al. conducted a similar study in collegiate swimmers which demonstrated that a period of sleep extension yielded improved trial times, turn times, and reaction times off the block.<sup>32</sup> Schwartz et al. studied serving accuracy following a 1-week period of sleep extension in collegiate tennis players, finding that there was a significant improvement in serving accuracy from baseline metrics.<sup>34</sup>

It can also be considered that optimizing sleep may transitively improve athletic performance through the reduction of injury risk, as training availability is an important determinant of athletic success.<sup>6,9</sup> Keeping young athletes healthy will allow for increased participation in training

and in turn, improved performance. The aforementioned metrics affected by sleep are summarized in Table 1.

### *The Role of Napping*

Following acute sleep deprivation, naps can be utilized to potentially mitigate the detrimental effects of sleep restriction. It has been found that a short daytime nap (10–30 minutes) following acute sleep restriction can lead to improved cognitive and physical performance as demonstrated by metrics such as accuracy, short-term memory, performance on psychomotor vigilance tasks, and sprint times.<sup>36–39</sup> Of note, studies evaluating the efficacy of naps did so in the setting of restricted sleep (1.5–4-hour reduction from baseline) rather than complete sleep deprivation.<sup>36–39</sup> Additionally, napping in the study groups occurred between 1:30 pm and 3:00 pm which may be a difficult time frame for youth athletes during the academic year given their school and sports scheduling.

### *Timing of Sleep*

The timing of sleep and sleep deprivation may be an important, though difficult, consideration for young athletes. Studies by Souissi et al. and Mejri et al. have provided evidence that losing beginning-of-night sleep (i.e., going to bed late) may have a less severe impact on athletic performance than losing end-of-night sleep (i.e., waking up early).<sup>40,41</sup> In these studies, sleep was restricted at either the beginning or end of the night by 3–4 hours, limiting the total duration of sleep to 3–4 hours. For this reason, if adequate sleep cannot be achieved, it may be beneficial for young athletes to prioritize the latter portion of their sleep.

## **Methods to Optimize Sleep**

Young athletes face a unique set of constraints in their efforts to optimize sleep, as they face concurrent demands of both athletics and academics, along with potential distractions from sleep. It is important to assess current sleep health to implement the appropriate interventions. Sleep can be tracked with most smartwatches, or a sleep journal can be kept for at least 2 weeks to evaluate baseline sleep patterns.<sup>42,43</sup> Additionally, it may be useful for physicians

**Table 1**  
**Metrics Impaired with Poor Sleep and Improved with Optimized Sleep**

Speed
Endurance
Reaction Time
Accuracy
Alertness
Subjective Fatigue
Mood and Overall Well-being
Reduced Injury Risk

to take a sleep history in their young athletes with tools such as the BEARS instrument (Bedtime problems, Excessive daytime sleepiness, Awakenings during the night, Regularity and duration of sleep, and Snoring), which records valuable sleep information and potentially identifies sleep problems in pediatric patients.<sup>44</sup> Following assessment of baseline sleep health, implementing sleep hygiene education can lead to significant improvements in sleep duration and quality in young athletes.<sup>45,46</sup> Education sessions focusing on the implementation of proper sleep hygiene practices have been demonstrated to be effective in improving sleep patterns, which may be beneficial for youth athletes to improve performance, recovery, and overall well-being.<sup>45–48</sup>

### *Sleep Hygiene Recommendations*

When aiming to optimize sleep, it is important to consider sleep duration, quality, and regularity. The following recommendations aim to address and improve each aspect of sleep hygiene and are summarized in Table 2. Youth athletes should avoid exposure to bright lights and LED screens (television, tablets, cell phones) in the hours leading up to bed, as studies have shown that exposure to such lights can inhibit the release of melatonin, an essential sleep regulating hormone.<sup>49,50</sup> In place of utilizing electronic devices, children can consider preparing

for bed with relaxing activities such as reading or listening to music at low volume.<sup>51,52</sup> Conversely, exposure to bright light in the morning can be beneficial for sleep hygiene. Exposure to early morning sunlight can help shift circadian rhythms to an earlier schedule, allowing patients to fall asleep earlier, thus increasing sleep duration.<sup>53</sup> For athletes whose geographic locations and schedules do not allow for awakening with sunlight, a sunrise-simulating alarm clock may provide similar benefit. If possible, bedroom temperature should remain between 60–67 degrees F (15–19 degrees C), as optimal ambient temperatures have been found to be important for efficient sleep.<sup>54-57</sup> Caffeine intake should be avoided, especially in the evening. While caffeine has been shown to have some benefits on athletic performance (improved endurance, concentration, and alertness)<sup>58</sup> it can have negative effects on sleep health. Caffeine consumed even 6 hours before bedtime has been found to reduce sleep time.<sup>59,60</sup> Additionally, the use of caffeine in young athletes can lead to dependence and discontinuation can cause headaches, irritability, and drowsiness.<sup>58</sup> As such, it is advised that young athletes avoid all forms of caffeine, including coffee, tea, and particularly energy drinks, which are often marketed to this young demographic. To address regularity of sleep schedule, it is important to maintain a consistent bedtime on both weekdays and weekends.<sup>61</sup> Of note, the evidence regarding the use of melatonin, an over-the-counter sedating medication, remains inconclusive. Some studies have shown that melatonin can help to synchronize circadian rhythms and improve the onset, duration, and quality of sleep.<sup>62</sup> However, in the athlete population, melatonin has not been reliably shown to benefit sleep or subsequent performance. Studies have found that ingestion of melatonin before bed can decrease alertness, reaction time, and short-term memory the following day while not improving subjective sleep quality.<sup>63</sup>

## Conclusion

Young athletes commonly suffer from both acute and chronic sleep deprivation. This has been linked to increased injury rates and decreased athletic and

**Table 2**  
**Methods to Optimize Sleep**

Limit screen time before bed
Read or listen to relaxing music before bed
Get exposure to sunlight in the early morning
Maintain optimal bedroom temperature of 60–67° F (15–19° C)
Avoid caffeine
Maintain consistent sleep schedule on weekdays and weekends

neurocognitive performance. Conversely, sleep optimization in young athletes can lead to improved athletic performance and greater competitive success. When aiming to optimize sleep, key elements such as sleep duration, quality, and regularity must be addressed. Clinicians can assess baseline sleep hygiene in young athletes and educate them on proper methods to optimize sleep.

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