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## The effect of sleep on physical performance, regeneration and risk of injuries in athletes- a literature review

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## ABSTRACT

Sleep is a fundamental physiological process essential for physical and cognitive functioning, recovery, and overall health. In athletes, adequate sleep duration and quality are particularly important due to high physical and psychological demands associated with training and competition. Insufficient or poor-quality sleep may impair athletic performance and post-exercise recovery and has also been suggested as a potential factor associated with an increased risk of sports-related injuries. Therefore, optimizing sleep has become an important component of athlete health, recovery, and performance management.

**Aims:** The aim of this review was to summarize current evidence on the relationship between sleep and athletic performance, post-exercise recovery, and sports-related injury risk.

**Methods:** A literature review was conducted using the PubMed/MEDLINE database. Articles published between January 2015 and September 2026 were considered. The search strategy included Medical Subject Headings (MeSH) and keywords related to sleep, athletes, athletic performance, recovery, fatigue, and sports injuries. Original studies, systematic reviews, meta-analyses, and relevant narrative reviews meeting the predefined eligibility criteria were included.

**Results:** Current evidence indicates that insufficient sleep and sleep deprivation may negatively affect several components of athletic performance, including endurance, strength and power, reaction time, technical skills, and perceived exertion. Adequate sleep appears to contribute to post-exercise recovery, while interventions such as sleep extension and napping may improve selected performance and recovery outcomes. Although insufficient or poor-quality sleep has been associated with an increased risk of injury in some athletic populations, evidence regarding sleep as an independent risk factor for sports-related injuries remains inconsistent.

**Conclusion:**

**Conclusion:** Adequate sleep is an important component of athletic performance and recovery. Insufficient sleep may impair selected physical and cognitive performance outcomes, whereas sleep optimization may support recovery and athletic performance. However, further prospective and well-controlled studies are required to clarify the relationship between sleep and sports-related injury risk.

**Keywords:** sleep; athletes; athletic performance; recovery; sleep deprivation; sleep quality; sports injuries

## INTRODUCTION

Sleep is a fundamental biological process that plays an essential role in maintaining physical and cognitive functioning, metabolic and endocrine regulation, immune function, and psychological well-being. In athletes, adequate sleep is particularly important because the ability to perform and recover is influenced not only by training load and nutrition but also by the quantity and quality of recovery between training sessions and competitions [1,2]. Consequently, sleep is increasingly regarded as an integral component of athletic preparation and recovery rather than merely a passive period of rest [1].

Athletes may be particularly susceptible to insufficient sleep and impaired sleep quality. Sport-specific factors, including high training loads, early-morning or late-evening training sessions, competition schedules, travel across time zones, and psychological arousal associated with competition, can interfere with normal sleep patterns [1,3]. In addition, non-sport-related factors such as stress, anxiety, lifestyle behaviours, and individual variability in sleep requirements may further influence sleep quantity and quality [1]. Evidence from athlete populations indicates that sleep problems are relatively common. Therefore, an individualized approach to sleep assessment and recommendations has been advocated, as a universal sleep-duration recommendation may not adequately reflect the needs of every athlete [1].

The relationship between sleep and athletic performance has received increasing scientific attention. Sleep loss may affect both physical and cognitive components of performance [2,4]. Depending on the duration and severity of sleep restriction, impaired sleep may influence endurance capacity, strength and power production, reaction time, decision-making, technical skills, and perceived exertion [2]. These effects are particularly relevant in competitive sport, where relatively small changes in physiological or cognitive performance may influence training quality and competition outcomes. More recent evidence continues to support the importance of sleep for athletic performance, although responses to sleep loss may differ according to the type of exercise, characteristics of the athlete, timing of sleep deprivation, and the performance outcome assessed [4].

The relationship between sleep and sport is also bidirectional. While sleep can influence an athlete's capacity to perform and recover, training and competition themselves can disrupt subsequent sleep [3,5]. This issue may be particularly relevant following evening competitions. Factors such as physiological arousal, exposure to light, post-competition nutrition, travel, and psychological activation may delay sleep onset and reduce sleep duration. Studies involving elite athletes have

demonstrated impaired sleep following night-time competition, potentially compromising the recovery period before subsequent training or competition [5]. Such effects may become especially important in sports characterized by congested competition schedules and limited recovery periods.

Sleep is also considered an important component of post-exercise recovery [3,6]. Recovery from training involves multiple physiological processes, including restoration of energy stores, regulation of the endocrine and immune systems, repair and remodelling of damaged tissues, and psychological recovery. Sleep may contribute to these processes through interactions with hormonal, inflammatory, and immune pathways [6]. Consequently, inadequate sleep may potentially interfere with optimal adaptation to training and recovery from exercise-induced physiological stress. However, the mechanisms linking sleep with muscle recovery remain complex, and evidence derived directly from athletic populations is more limited than evidence concerning general performance outcomes [6].

Given the potential importance of sleep for performance and recovery, interventions designed to improve athletes' sleep have also attracted considerable attention. Strategies investigated in the literature include sleep extension, daytime napping, sleep-hygiene education, manipulation of light exposure, mindfulness-based approaches, and modification of behaviours surrounding bedtime [7]. A systematic review of 25 intervention studies found that sleep extension and napping were among the most frequently investigated and promising approaches for improving sleep and subsequent physical or cognitive performance [7]. Nevertheless, the available literature remains heterogeneous, and the effectiveness of specific interventions may depend on the athlete, sport, training schedule, baseline sleep characteristics, and intervention protocol.

Another clinically relevant aspect is the potential relationship between insufficient or poor-quality sleep and sports-related injury. Several mechanisms could theoretically contribute to such an association. Sleep loss may impair reaction time, attention, decision-making, motor control, and recovery processes, potentially increasing an athlete's susceptibility to injury [2,8]. Nevertheless, an association between sleep and injury should not automatically be interpreted as evidence of causation. Injury risk in sport is multifactorial and may be influenced simultaneously by training load, previous injury, competition exposure, psychological factors, fatigue, and numerous other variables.

Importantly, the current evidence regarding sleep as an independent risk factor for sports injury remains inconsistent. A systematic review of 12 prospective cohort studies in adult athletic populations found limited evidence supporting an association between poor sleep and subsequent injury and concluded that available evidence did not support poor sleep as an independent risk factor

for sport- or physical training-related injuries in adults [8]. Similarly, research in specific sports such as football suggests potential relationships between sleep, training load, performance, and injury, but methodological heterogeneity and the predominance of observational designs limit causal interpretation [9]. Therefore, this aspect of the sleep–athlete relationship requires particularly careful evaluation.

Taken together, current evidence suggests that sleep represents an important component of athletic health and performance, but the strength of evidence differs depending on the outcome considered. The effects of sleep deprivation on several aspects of physical and cognitive performance are relatively well documented, whereas the relationships between sleep, physiological recovery, and particularly injury risk remain less definitive [2,6,8]. Furthermore, substantial methodological differences exist between studies in terms of athlete populations, sports disciplines, methods of sleep assessment, definitions of insufficient sleep, and outcome measures.

Therefore, the aim of this narrative review was to evaluate and synthesize scientific evidence published between 2015 and 2026 regarding the relationship between sleep and athletic performance, post-exercise recovery, and sports-related injury risk. Particular attention was given to the effects of insufficient sleep and sleep deprivation on physical performance, the role of sleep in recovery processes, and the evidence supporting a potential association between sleep characteristics and injury risk in athletes.

### **Aim of the study**

The aim of this review was to evaluate and summarize the current scientific evidence regarding the relationship between sleep and athletic performance, post-exercise recovery, and sports-related injury risk. Particular attention was given to the effects of sleep duration, sleep quality, sleep deprivation, and sleep restriction on physical and cognitive performance, as well as to the role of sleep in recovery processes and its potential association with injury risk among athletes.

Additionally, the review aimed to assess the potential benefits of sleep optimization strategies, including sleep extension and daytime napping, and to identify current limitations and gaps in the available evidence.

## **METHODOLOGY**

A narrative literature review was conducted to evaluate the relationship between sleep and athletic performance, post-exercise recovery, and sports-related injury risk. The literature search was performed using the PubMed/MEDLINE database and included articles published between January 2015 and September 2026.

The literature search was based on keywords related to sleep, athletic performance, recovery, and sports injuries. The main search terms included: sleep, sleep quality, sleep duration, sleep deprivation, sleep restriction, sleep extension, athletes, athletic performance, physical performance, recovery, fatigue, muscle recovery, and sports injuries. Relevant terms were combined during the database search to identify publications corresponding to the objectives of the review.

Studies were considered eligible if they were published in English between 2015 and 2026 and investigated athletes or physically active individuals. Original research articles, systematic reviews, meta-analyses, and relevant narrative reviews were considered. Studies were required to evaluate sleep-related parameters and at least one outcome associated with athletic performance, post-exercise recovery, fatigue, or sports-related injury risk.

Studies published before 2015, animal studies, publications unrelated to sport or physical activity, and studies that did not evaluate sleep-related parameters or outcomes relevant to the objectives of this review were excluded.

The selection process included screening the titles and abstracts of identified publications, followed by a detailed assessment of potentially relevant articles. Information concerning study design, population, sample size, sport discipline, sleep assessment methods, investigated outcomes, main findings, and study limitations was extracted from the included publications.

Due to differences in study designs, populations, sleep assessment methods, and outcome measures, the findings were synthesized narratively. The evidence was organized into three main areas: sleep and athletic performance, sleep and post-exercise recovery, and sleep and sports-related injury risk.

## RESULTS AND DISCUSSION

### *Sleep characteristics in athletes*

The reviewed literature indicates that insufficient sleep and impaired sleep quality are common among athletes and may be influenced by the specific demands of training and competition. Elite athletes are exposed to several factors that may negatively affect sleep, including early-morning training sessions, evening competitions, increased training load, travel, jet lag, and psychological stress associated with competition [1,10]. In a systematic review and meta-analysis including 54 studies, Roberts et al. demonstrated that many elite athletes failed to achieve recommended total sleep time and sleep efficiency during both training and competition periods. Total sleep time was approximately 60 minutes shorter on the night of competition compared with preceding nights, while evening competition was associated with an even greater reduction in sleep duration [10].

The discrepancy between sleep need and actual sleep duration is also important. Sargent et al. investigated 175 elite athletes representing 12 individual and team sports. The athletes reported requiring an average of 8.3 hours of sleep to feel rested, whereas their objectively assessed habitual sleep duration averaged only 6.7 hours. Moreover, 71% of participants accumulated a sleep deficit of at least one hour compared with their self-reported sleep need [11]. These findings suggest that insufficient sleep among athletes should not necessarily be regarded as an isolated event but may represent a persistent feature of the training and competition environment.

Sleep disturbances are not limited to sleep duration. Tuomilehto et al. evaluated 107 professional ice hockey players and reported significant sleep problems in approximately one-quarter of the athletes. Importantly, structured sleep counselling and individualized treatment were associated with improved sleep quality [12]. This finding supports the practical value of identifying sleep problems rather than assuming that poor sleep is an unavoidable consequence of professional sport.

### *Sleep and athletic performance*

The available evidence consistently indicates that sleep deprivation can adversely affect athletic performance, although the magnitude of impairment varies according to the type of physical task, duration and timing of sleep loss, and characteristics of the studied population [2,4]. The effects appear to involve both physiological and cognitive components of performance.

Recent quantitative evidence strengthens this relationship. Gong et al. performed a systematic review and meta-analysis of 27 publications and found a significant negative effect of acute sleep deprivation on overall athletic performance. High-intensity intermittent exercise, skill control, speed, aerobic endurance, and explosive power were all negatively affected. Interestingly, performance impairment was greater when testing was conducted in the afternoon than in the morning following sleep deprivation [13].

Endurance performance appears to be particularly susceptible to inadequate sleep. A systematic review and meta-analysis by Lopes et al., incorporating 31 studies and 478 participants, demonstrated a moderate negative effect of sleep deprivation on endurance performance (standardized mean difference  $-0.52$ ). The effect was greater for exercise lasting more than 30 minutes [14]. These findings may be particularly relevant to endurance athletes and athletes participating in prolonged competitions.

The relationship between sleep and muscular strength appears more complex. A systematic review by Knowles et al. including 17 studies found that complete sleep deprivation generally had little effect on some measures of muscle strength, whereas consecutive nights of sleep restriction could reduce force production during multi-joint movements. The authors also reported inconsistent findings regarding hormonal responses to resistance exercise [15]. Therefore, it would be inappropriate to conclude that every form of sleep loss causes a uniform reduction in muscular strength.

This variability is important when interpreting the literature. Athletic performance is multidimensional, and the response to sleep deprivation cannot be reduced to a single outcome. Endurance, speed, power, technical performance, reaction time, decision-making, and perceived exertion may respond differently to sleep loss [2,4,13-15]. Differences in experimental protocols also complicate comparisons between studies. Some studies investigate total sleep deprivation, whereas others examine partial restriction or naturally occurring poor sleep. Consequently, the magnitude of the reported effects should be interpreted in the context of the specific sleep disturbance studied.

### ***Sleep and post-exercise recovery***

Sleep represents an important component of recovery following exercise and competition [3,4]. Recovery is a complex process involving restoration of physiological homeostasis, tissue repair, metabolic regulation, immune and endocrine responses, as well as psychological recovery. The available evidence suggests that sleep may interact with several of these processes [6].

Chennaoui et al. described potential mechanisms linking sleep with recovery from exercise-induced muscle injury, emphasizing interactions between sleep, growth hormone secretion, the insulin-like growth factor system, inflammatory processes, and immune function [6]. These mechanisms provide biological plausibility for the relationship between sleep and recovery, although mechanistic evidence should not automatically be interpreted as proof that a specific amount of additional sleep directly accelerates muscle repair in athletes.

Competition itself can interfere with this recovery opportunity. Fullagar et al. reported substantially reduced sleep duration following night matches in elite football players compared with both daytime matches and regular training days [5]. More recent real-world research involving elite Australian football and rugby league athletes similarly found delayed sleep timing, shorter total sleep time, and poorer sleep quality following competition compared with free days [16]. Therefore, the period in which recovery is particularly important may paradoxically be one in which athletes experience substantial sleep disruption.

This relationship is likely bidirectional. Training and competition may impair sleep, while inadequate sleep may subsequently compromise readiness for further training and competition [3,10]. Consequently, sleep should be considered alongside other components of recovery rather than as an isolated factor. Kölling et al. emphasized that sleep monitoring may provide useful information concerning recovery and performance, but interpretation should account for individual differences and the specific training and competition context [17].

#### Sleep optimization and performance

Because inadequate sleep may compromise performance and recovery, several studies have examined whether interventions aimed at improving sleep can provide measurable benefits. These interventions include sleep extension, daytime napping, sleep-hygiene education, light manipulation, mindfulness-based interventions, and modification of post-exercise routines.

Bonnar et al. systematically reviewed sleep interventions in competitive athletes and included 10 studies involving 218 participants. Among the interventions investigated, sleep extension demonstrated particularly promising effects on subsequent performance, although benefits were not consistent across all outcomes [18].

However, evidence concerning sleep extension should be interpreted cautiously. Silva et al. identified only two studies that fulfilled the criteria of their systematic review of sleep extension and sports performance. Although several performance outcomes improved, the quality of evidence ranged from very low to moderate, preventing strong conclusions [19].

A subsequent systematic review by Cunha et al. included 25 intervention studies and provided broader evidence. Sleep extension and daytime napping were among the most frequently investigated and most effective strategies for improving sleep and selected physical or cognitive performance outcomes [7]. Nevertheless, the authors emphasized the limited amount of high-quality evidence. This progression in the literature is important: newer reviews include more studies, but methodological heterogeneity remains a significant limitation.

Sleep hygiene alone may not always translate into improved physical recovery. In a randomized crossover study involving 20 football players following late-night matches, an acute sleep-hygiene strategy was investigated as a method of improving sleep and post-match recovery [20]. This highlights an important practical consideration: educational or behavioural interventions may improve certain sleep outcomes without necessarily producing equivalent improvements in every physiological performance or recovery marker.

Taken together, current findings suggest that increasing sleep opportunity and strategic napping are promising approaches, particularly in athletes with inadequate habitual sleep [7,18,19]. However, individualized interventions may be more appropriate than universal recommendations because sleep requirements, competition schedules, chronotype, training load, and baseline sleep patterns vary substantially between athletes [1,11].

### ***Sleep and sports-related injury risk***

The relationship between sleep and injury represents one of the most clinically relevant but also one of the least definitive areas identified in the reviewed literature. Several mechanisms could explain a potential association. Insufficient sleep may affect reaction time, attention, decision-making, neuromuscular control, fatigue, and physiological recovery, all of which could theoretically contribute to injury susceptibility [4,21].

Huang and Ihm reviewed evidence concerning sleep and injury and reported that chronic sleep durations of  $\leq 7$  hours, particularly when sustained for at least 14 days, had been associated in previous

studies with an approximately 1.7-fold greater risk of musculoskeletal injury [21]. However, the authors emphasized that sleep should be considered as one component of an athlete's overall injury-risk profile rather than as an isolated determinant.

This distinction is supported by the systematic review by Dobrosielski et al. [8]. After evaluating 12 prospective cohort studies involving adult athletic populations, the authors concluded that the available evidence was insufficient to establish poor sleep as an independent risk factor for sport- and physical-training-related injuries [8]. This finding is particularly important because an observed association between short sleep and injury does not establish a causal relationship.

Evidence from football illustrates the same uncertainty. Clemente et al. systematically reviewed 32 studies examining sleep in relation to performance, training load, and injuries in football players. Some studies suggested that sleep restriction was associated with impaired performance and a greater number or severity of musculoskeletal injuries; however, the overall evidence was inconsistent [9].

A recent systematic review published in 2026 examining sleep, stress, recovery, and injury risk in football selected 18 studies and again emphasized the complex interaction between sleep indicators, stress, recovery, and injury vulnerability [22]. This supports a multifactorial interpretation of injury risk. Rather than considering inadequate sleep as a direct and isolated cause of injury, sleep may interact with training load, psychological stress, previous injuries, recovery status, and other individual factors.

### ***Overall interpretation of the evidence***

Overall, the reviewed evidence supports an important relationship between sleep and athletic functioning, but the strength of evidence differs across the three major domains investigated. Evidence concerning the adverse effects of sleep deprivation on selected aspects of physical and cognitive performance is relatively strong, particularly for endurance performance and several measures of sport-specific ability [13-15]. In contrast, evidence regarding recovery is biologically plausible and supported by observational and interventional research, but substantial methodological variability remains [6,7,17-20].

The relationship between sleep and injury risk requires the greatest caution. Although several studies and reviews report associations between inadequate sleep and injuries, current evidence does not establish inadequate sleep as an independent causal factor for sports injuries in adult athletes

[8,9,21,22]. Future prospective studies should use standardized definitions of sleep deficiency and sports injury, objective sleep measurements where feasible, and repeated assessments of training load, recovery, and other potential confounding factors.

More recent literature continues to emphasize an individualized approach. A 2026 review highlighted the complex interactions between physical activity, sleep, athletic performance, recovery, mental health, napping, and circadian factors [23]. Therefore, sleep optimization should be integrated into a broader recovery strategy rather than considered a single intervention capable of independently determining performance or injury risk.

## **CONCLUSIONS**

Sleep is an important component of athletic performance, post-exercise recovery, and overall athlete health. Current evidence indicates that insufficient sleep, sleep restriction, and poor sleep quality may negatively affect several aspects of physical and cognitive performance, particularly endurance, reaction time, technical skills, and perceived exertion. However, the magnitude of these effects varies depending on the type and duration of sleep disturbance, the characteristics of the athlete, and the performance outcome assessed.

Adequate sleep also appears to play an important role in post-exercise recovery through its involvement in physiological, metabolic, endocrine, and immune processes. Strategies aimed at improving sleep, particularly sleep extension and daytime napping, may provide benefits for selected performance and recovery outcomes. Nevertheless, the effectiveness of sleep interventions varies between individuals, supporting the need for an individualized approach to sleep management in athletes.

Although insufficient sleep and poor sleep quality have been associated with sports-related injuries in some populations, the available evidence does not clearly establish sleep disturbance as an independent causal risk factor for injury. Sports injuries have a multifactorial etiology, and sleep should therefore be considered alongside other relevant factors, including training load, previous injury, fatigue, psychological stress, and recovery status.

Overall, incorporating sleep assessment and optimization into athletes' recovery strategies may contribute to maintaining performance and supporting recovery. Further high-quality prospective and

interventional studies using standardized methods of sleep and injury assessment are required to better determine the role of sleep in injury prevention and to establish evidence-based sleep recommendations for different athletic populations.

## **DISCLOSURE**

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## **CONFLICT OF INTEREST**

The authors declare that they have no conflict of interest.

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