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Review of the literature

Physical activity, athletic performance, and recovery: The role of sleep

Activité physique, performances sportives et récupération : le rôle du sommeil

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ABSTRACT

Background: Physical activity is widely recognized for its benefits on physical and mental health. However, interactions between sleep, athletic performance, and recovery remain complex and incompletely understood. This narrative review synthesizes recent evidence on the relationships between physical activity, mental health, sleep, and performance, and outlines potential therapeutic perspectives.

Methods: We reviewed recent meta-analyses, randomized controlled trials, observational studies, and expert consensus statements addressing physical activity, sleep, mental health, athletic performance, recovery, napping, and circadian factors in both general and athletic populations.

Results: Physical activity shows a clear inverse dose–response relationship with depression risk, with even moderate levels conferring significant mental health benefits. Regular physical activity (≥ 150 min/week of moderate-to-vigorous activity) significantly reduces insomnia symptoms, improves sleep efficiency, and is associated with reduced anxiety and depressive symptoms. Sleep is a key determinant of athletic performance, yet 50–78% of athletes report sleep complaints, often related to training schedules, competitions, intense light exposure, and travel-induced jet lag. Sleep deprivation impairs performance, particularly in sports requiring fine motor skills and sustained cognitive functioning and contributes to overtraining and prolonged performance decrements. Adequate sleep duration and sleep extension are associated with improved recovery and sport-specific performance. Napping may support recovery and vigilance, but its benefits depend on duration and timing, with a risk of sleep inertia following long naps (> 30 min).

Conclusion: Sleep represents a pillar of mental health, athletic performance, and recovery. Integrating sleep-aware training schedules, circadian principles, and individualized physical activity programs may optimize both health, performance and recovery outcomes.

R É S U M É

Contexte : L'activité physique est largement reconnue pour ses bénéfices sur la santé physique et mentale. Toutefois, les interactions entre sommeil, performance sportive et récupération demeurent complexes et encore incomplètement comprises. Cette revue narrative vise à synthétiser les données récentes portant sur les relations entre activité physique, santé mentale, sommeil et performance, et à discuter des perspectives thérapeutiques associées.

Méthodes : Une revue de la littérature a été réalisée à partir de méta-analyses récentes, d'essais contrôlés randomisés, d'études observationnelles et de recommandations d'experts portant sur l'activité physique, le sommeil, la santé mentale, la performance sportive, la récupération, la sieste et les facteurs circadiens, chez des populations générales et sportives.

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Résultats : L'activité physique présente une relation dose-réponse inverse claire avec le risque de dépression, des niveaux même modérés étant associés à des bénéfices significatifs pour la santé mentale. Une activité physique régulière (≥ 150 minutes par semaine d'intensité modérée à vigoureuse) réduit significativement les symptômes d'insomnie, améliore l'efficacité du sommeil et s'accompagne d'une diminution des symptômes anxieux et dépressifs. Le sommeil constitue un déterminant majeur de la performance sportive ; pourtant, 50 à 78 % des athlètes rapportent des plaintes de sommeil, fréquemment liées aux contraintes d'entraînement, aux compétitions, à l'exposition lumineuse intense et au décalage horaire. La privation de sommeil altère les performances, en particulier dans les disciplines nécessitant une motricité fine et un fonctionnement cognitif soutenu, et contribue au surentraînement ainsi qu'à des baisses prolongées de performance. Une durée de sommeil adéquate et l'extension du temps de sommeil sont associées à une meilleure récupération et à une amélioration des performances spécifiques au sport pratiqué. La sieste peut soutenir la récupération et la vigilance, mais ses effets dépendent de sa durée et de son *timing*, avec un risque d'inertie du sommeil après des siestes prolongées (> 30 minutes).

Conclusion : Le sommeil constitue un pilier central de la santé mentale, de la performance sportive et de la récupération. L'intégration de stratégies d'entraînement tenant compte du sommeil, des principes circadiens et de programmes d'activité physique individualisés apparaît essentielle pour optimiser les bénéfices sur la santé, la performance et la récupération.

1. Introduction

The relationship between physical activity and sleep has attracted growing interest among both healthcare professionals and researchers. Physical activity is associated with well-established benefits for physical and mental health. However, its effects on sleep and athletic performance are not always well understood. On the one hand, moderate physical activity has been consistently shown to improve sleep quality and cognitive functioning [1,2]. On the other hand, certain sporting practices—particularly intensive training or exercise performed late in the day—may disrupt sleep-wake cycles. This review explores the interactions between physical activity, mental health, sleep, and performance, drawing on recent data and potential therapeutic perspectives (Fig. 1).

2. Physical activity and mental health

Physical activity is widely recognized for its beneficial effects on mental health (Fig. 2). A very recent meta-analysis demonstrated a clear inverse dose-response relationship between physical activity and the risk of depression [2]. For example, 2.5 hours of brisk walking per week was associated with a 25% reduction in depression risk, while 1.25 hours per week was associated with an 18% reduction in depression risk. This relationship was particularly strong among sedentary individuals, for whom even small increases in physical activity resulted in significant mental health benefits. The authors concluded that healthcare professionals should systematically encourage increases in physical activity to improve mental health outcomes [3].

Physical activity contributes to stress regulation, anxiety reduction, and increased release of endorphins, endogenous opioids, and endocannabinoids, which are associated with well-being [4]. In addition, it

improves cognitive functions such as attention, memory, and decision-making, with effects that may persist for up to two hours after exercise [3,5].

3. Physical activity and sleep

Physical activity also plays a key role in improving sleep quality (Fig. 3). Studies show that regular exercise programs involving at least 150 minutes per week of moderate-to-vigorous physical activity – corresponding to minimum international recommendations – significantly reduce insomnia symptoms [6–8]. A randomized controlled trial demonstrated that participants enrolled in an exercise program experienced an average 4-point reduction in the Insomnia Severity Index (ISI), compared with a 1–2 point reduction in the control group [6]. These improvements were also accompanied by reductions in anxiety and depressive symptoms [9]. Further reinforcing the link between physical activity and sleep regulation [6].

A recent study examined the associations between 24-hour time-use composition (sleep, sedentary behavior, light physical activity, and moderate-to-vigorous physical activity) and multiple dimensions of healthy sleep in 1168 children and 1360 adults. Participants wore wrist actigraphy devices for eight consecutive days. The results showed that the 24-hour activity composition was significantly associated with all dimensions of healthy sleep in both children and adults. Greater time allocated to sleep was associated with earlier bedtimes, later wake times, lower sleep efficiency, but more regular sleep patterns [10]. This study highlights the importance of considering sleep within a 24-hour behavioral framework. Contrary to common assumptions, physical activity—approximately one hour per day in children and around two hours per week in adults, in line with public health recommendations—was associated with less daytime fatigue. Physical activity thus appears to promote “healthy fatigue,” greater daytime energy, better sleep quality (efficiency, sleep onset, and awakening), and more regular sleep patterns [10].

4. Sleep and athletic performance

Sleep is a key determinant of athletic performance (Fig. 4). Surveys consistently show that athletes perceive sleep as a critical target for improving both performance and recovery [11]. However, many athletes report sleep disturbances. Between 50% and 78% of athletes report difficulties sleeping, and 22–26% report severe sleep disturbances [12]. These disturbances include prolonged sleep onset latency, reduced total sleep time (often < 7 hours), and a subjective feeling of non-restorative sleep [12]. Sleep disruption is often exacerbated by training schedules, late-evening competitions, exposure to intense LED lighting, and travel involving time zone changes [12]. In addition, elite athletes may present



Fig. 1. Sleep as the foundation of sports performance and optimal recovery.



Fig. 2. Summary of links between physical activity, sleep and mental health.

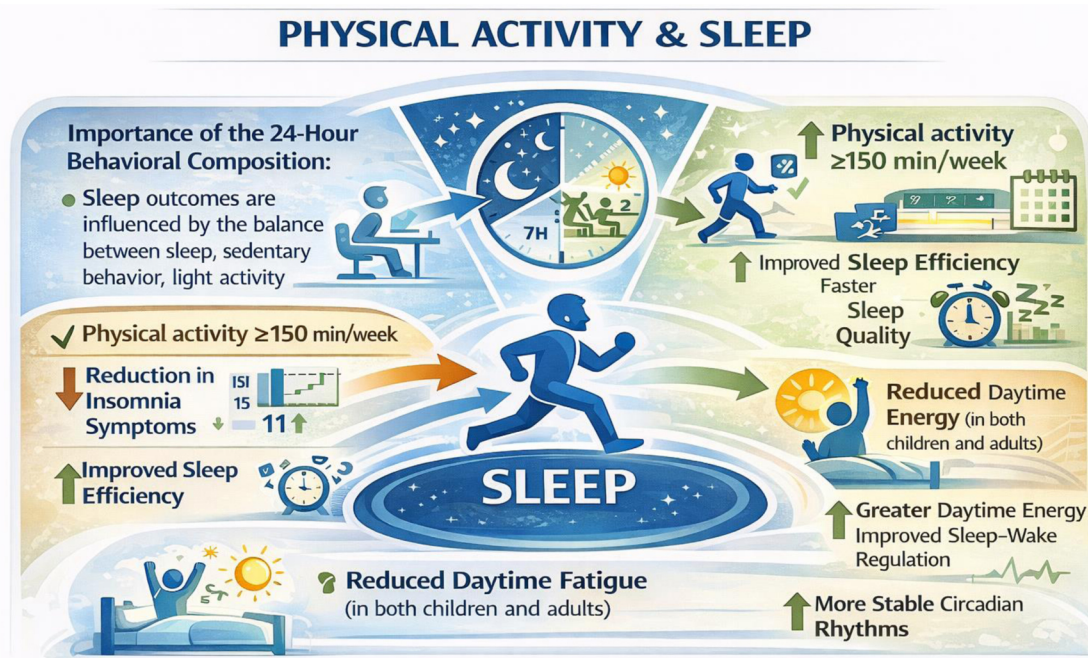


Fig. 3. Summary of links between physical activity and sleep.

comorbid sleep disorders, such as obstructive sleep apnea, reported in 8–14% of American football players [13,14].

Risk factors for sleep disturbances include female sex, age over 25 years, hyperarousal, and perfectionism [11,12]. Other contributing factors relate to the structure and demands of training and competition. For example, an 11% reduction in total sleep time (TST) has been observed in women’s basketball players during weeks with two matches. A decrease in TST has also been reported during the first two weeks of training camps, followed by a rebound increase two weeks later.

Sleep alterations represent prodromal signs of overtraining syndrome and are associated with performance decrements that may persist for several months [11,12].

Circadian rhythms also play a major role. Training or competition schedules occurring before 8 a.m. or after 6 p.m. are associated with a reduction in TST of 2–3 hours [11,12]. These extreme schedules are linked to increased caffeine or alcohol consumption, exposure to intense artificial light (stadium lighting up to 2000 lux, screens), heightened stress

signaling (increased cortisol secretion), elevated core body temperature, and activation of the sympathetic nervous system [11,12].

Another well-established factor in sport is travel-related jet lag, particularly eastward travel, which leads to a reduction in TST [11,12]. Specifically, a decrease of approximately 3 hours has been observed after travel in economy class compared with business class, an 85-minute reduction for away games compared with home games, and a marked reduction when athletes return home on the evening of an away competition (sleeping on-site is therefore recommended) [11,12]. Finally, studies show that in high-impact sports (e.g., American football versus soccer), TST is more reduced compared with other disciplines.

As a consequence, significant impairments in performance are observed [11,12]. The effects of sleep deprivation vary depending on the type of sport. Disciplines requiring fine motor skills and sustained cognitive functioning—such as tennis serving accuracy, reaction time in handball goalkeepers, or soccer shooting accuracy—are particularly affected, whereas endurance sports appear to be less impacted

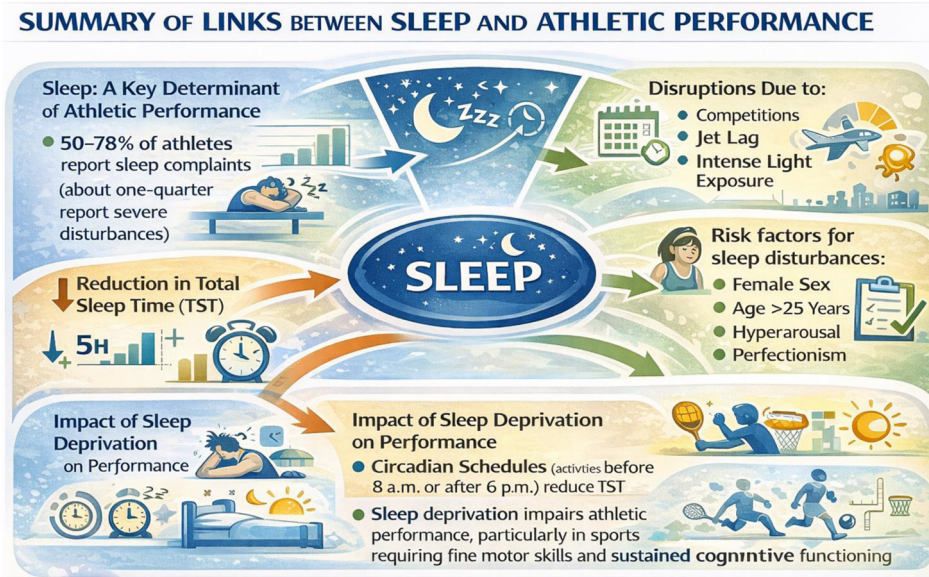


Fig. 4. Summary of links between sleep and athletic performance.



Fig. 5. Summary of links between sleep and recovery.

[11,12]. After 30 hours of sleep deprivation, a marked reduction in sprint speed and a decrease in muscle glycogen concentration have been observed, illustrating the direct impact on strength and physical performance. After 64 hours without sleep, muscular strength declines, while power output and resistance to fatigue are reduced after 36 hours [12].

It should be emphasized that relatively few studies have been conducted under ecologically valid conditions. Sleep deprivation significantly impairs decision-making, reaction time, and working memory, in association with reduced metabolism in key brain regions such as the prefrontal cortex, thalamus, and cerebellum [7]. Importantly, the impact of sleep loss varies according to individual chronotype, influencing physical performance differently depending on the time of day [11,12]. Chronotype-related differences in performance have been demonstrated in athletes, with evening-types performing better later in the day, highlighting the importance of individualized scheduling [15].

5. Sleep and recovery

Sleep plays a central role in recovery (Fig. 5) following intense physical exertion [11,12]. Nevertheless, there are relatively few studies specifically addressing recovery in elite athletes. Athletes who obtain high-quality sleep show better physiological and subjective recovery, as observed in volleyball players and soccer players [11,12]. Sleep is associated with the restoration of bodily functions through mechanisms such as muscle repair, maintenance of molecular homeostasis, and synaptic plasticity [11,12].

An increase in total sleep time (TST) has been associated with improvements in sports performance [11,12]. For example, in basketball players, increased TST led to improved free-throw and three-point shooting accuracy. In swimmers, increased speed and faster reaction times were observed. In tennis players, extended sleep duration was associated with a higher percentage of successful serves. Again, results



Fig. 6. Summary of the role of napping in performance and recovery.

for endurance sports are less consistent. Recent data from elite esports athletes further nuance these findings [16]. In a prospective intervention study conducted in competitive Valorant players, sleep counseling did not result in a significant increase in total sleep time, highlighting the difficulty of achieving behavioral sleep extension in elite esports contexts. Nevertheless, improvements in neurocognitive reaction times were observed, along with modest but significant improvements in heart rate variability, suggesting potential benefits on autonomic regulation and cognitive processing even in the absence of measurable sleep extension [16]. No significant improvements were observed in in-game performance metrics [16]. Taken as a whole, these experimental sleep extension studies in elite athletes demonstrate that increasing total sleep time leads to significant improvements in sport-specific performance, reaction time, mood, and subjective recovery, supporting sleep extension as an effective performance-enhancing strategy [17].

6. The role of napping in performance and recovery

The use of napping in sport is frequently discussed by athletes, coaches, and healthcare professionals. Scientific evidence suggests that napping can be an effective tool for optimizing performance and recovery, but its effects depend on several factors, including nap duration, type of physical demand, and context. Napping should therefore be used cautiously and ideally tested prior to competitions to avoid deleterious effects on alertness and coordination [18].

Several systematic reviews, including those by Heller et al. [19], Cunha et al. [20], and Bonnar et al. [21], have shown that naps can improve muscular and cognitive recovery, emotional regulation and mood, reduce stress, optimize vigilance, and reduce perceived exertion.

However, observed benefits vary according to nap duration and task demands (Fig. 6):

- short naps (< 20 minutes): associated with improved alertness and reflexes and modest improvements in neuromuscular performance, such as enhanced jump performance in netball. No effect has been observed on sprint performance in cyclists;



Fig. 7. Summary regarding napping and jet lag recovery.

Table 1

Recommendations for jet lag and athletes.

General recommendations:

Jet lag symptoms may occur as soon as there is a time difference of two time zones between the departure and arrival locations.

During short stays (2–3 days), full resynchronization of the internal clock may not be achievable. In such cases, it may be preferable not to fully adapt to local time

Ensure optimal sleep conditions: regular sleep–wake schedules, a cool, dark, and quiet bedroom, appropriate mattress and pillow, avoidance of screens in bed, alcohol, and stimulants

In general, eastward travel is more difficult to adapt to than westward travel, as the human circadian clock has an intrinsic period slightly longer than 24 hours, making phase delays easier than phase advances. The recommendations below are optional and aim to facilitate adaptation

To optimize recovery in athletes:

Allow at least 24 hours of rest before resuming intensive training to mitigate the effects of jet lag on vigilance and muscular recovery

Favor naps lasting 20–90 minutes depending on physiological needs and accumulated fatigue, while avoiding late-afternoon naps that may interfere with nocturnal sleep

Schedule naps during the circadian trough, typically in the early afternoon after lunch, when physiological sleep pressure is naturally increased

Wait at least 30 minutes after waking before engaging in intense training, as residual jet lag effects and sleep inertia may transiently impair coordination, vigilance, and reaction time, increasing injury risk

Managing eastward travel (phase advance)

→ sleep signals occur too late relative to local time and must be advanced

Before departure

Ensure adequate sleep in the days before travel

Gradually advance bedtime and wake time

Reinforce early morning awakening with morning light exposure (natural light or light therapy)

Limit evening light exposure to facilitate earlier sleep onset (reduce screen use; blue-light-filter glasses if screens are used)

During the flight

Set your watch to the destination time upon boarding

Limit alcohol, caffeine, and food intake

Try to sleep during the flight

Wear compression stockings

After arrival

Expose yourself to morning light (immediately if time difference < 6 h; later in the morning if > 6 h)

Use screens or light therapy in the morning if needed

Prefer outdoor morning activity (≥ 30 minutes of walking or jogging)

Avoid sunglasses in the morning; wear sunglasses in the afternoon

Favor physical activity in mid- to late morning

Melatonin (immediate or prolonged release) may be taken 30 minutes before bedtime at local time

Managing westward travel (phase delay)

→ sleep signals occur too early relative to local time and must be delayed

Before departure

Ensure adequate sleep

Gradually delay bedtime and wake time

Increase evening light exposure (natural light or light therapy)

Evening screen exposure may be used exceptionally (not in bed)

During the flight

Set your watch to destination time

Limit alcohol, caffeine, and heavy meals

Try to sleep during the flight

Wear compression stockings

After arrival

Expose yourself to late-afternoon or early-evening light

Use screens or light therapy in the evening if needed

Wear sunglasses in the morning; avoid sunglasses in the afternoon

Engage in physical activity in the afternoon or evening

Melatonin taken at midnight local time may help (avoid early evening intake)

- naps of 20–30 minutes: appear to optimize cognitive performance, particularly in sports requiring rapid decision-making and intense concentration (e.g., karate), without significantly affecting immediate physical performance;
- long naps (> 60 minutes): may promote improved muscular recovery but carry an increased risk of sleep inertia upon awakening, potentially impairing coordination, increasing reaction time, and reducing vigilance, which may negatively affect immediate performance and increase injury risk.

Napping is also used to facilitate recovery from jet lag in athletes [19] (Fig. 7). Jet lag represents a major challenge for professional athletes, particularly during international competitions or extended tours.

Specific recommendations can be formulated to optimize recovery following travel across multiple time zones [19]:

- allow at least 24 hours of rest before resuming intensive training to mitigate the effects of jet lag on vigilance and muscular recovery;
- favor naps lasting 20–90 minutes depending on physiological needs and accumulated fatigue, while avoiding late-afternoon naps that may interfere with nocturnal sleep;
- schedule naps during the circadian trough, typically in the early afternoon after lunch, when physiological sleep pressure is naturally increased;

Table 2
Global summary of the role of sleep in physical activity, athletic performance, and recovery.

Physical activity and mental health	Physical activity and sleep	Sleep and athletic performance	Sleep, napping and recovery
Physical activity reduces the risk of depression: – Even moderate amounts of physical activity (1.25 hours/week) confer meaningful mental health benefits	Importance of the 24-hour behavioral composition: – Sleep outcomes are influenced by the balance between sleep, sedentary behavior, light activity, and moderate-to-vigorous physical activity	Sleep: a key determinant of athletic performance	Sleep is essential for muscle recovery, molecular homeostasis, and synaptic plasticity
Inverse dose–response relationship between physical activity and depression	Physical activity (> 150 min/week of moderate to vigorous activity) improves sleep	50–78% of athletes report sleep complaints (about one-quarter report severe disturbances)	Improved athletic performance with increased sleep duration
Regular physical activity contributes to stress regulation and anxiety reduction	Reduction in insomnia symptoms	Disruptions due to competitions, jet lag, and intense light exposure	High-quality sleep promotes physiological recovery
Increased release of endorphins, endogenous opioids, and endocannabinoids, biological mediators associated with improved mood and subjective well-being	Improved sleep efficiency, faster sleep onset, and better subjective sleep quality	Reduction in total sleep time (TST)	Short naps (< 20 minutes): associated with improved alertness and reflexes and modest improvements in neuromuscular performance
Improvement in cognitive functions (attention, memory, decision-making)	Improved regularity of rhythms and sleep quality: – Earlier bedtimes, later wake times, and more regular sleep patterns, despite slightly lower sleep efficiency with longer sleep duration	Impact of sleep deprivation on performance	Risk of sleep inertia with naps > 30 min, potentially reducing performance
Small increases in physical activity yield substantial mental health benefits in inactive populations, highlighting a low threshold for clinical impact	Associated with reduced daytime fatigue (in both children and adults)	Circadian schedules (activities before 8 a.m. or after 6 p.m.) → reduce TST	Naps of 20–30 minutes: appear to optimize cognitive performance, particularly in sports requiring rapid decision-making and intense concentration (e.g., karate), without significantly affecting immediate physical performance
	Overall effects: Greater daytime energy, improved sleep–wake regulation, and more stable circadian rhythms	Risk factors for sleep disturbances include female sex, age > 25 years, hyperarousal, and perfectionism	Long naps (> 60 minutes): may promote improved muscular recovery but carry an increased risk of sleep inertia upon awakening, potentially impairing coordination, increasing reaction time, and reducing vigilance, which may negatively affect immediate performance and increase injury risk
		Sleep deprivation impairs athletic performance, particularly in sports requiring fine motor skills and sustained cognitive functioning	Napping is also used to facilitate recovery from jet lag in athletes

- wait at least 30 minutes after waking before engaging in intense training, as residual jet lag effects and sleep inertia may transiently impair coordination, vigilance, and reaction time, increasing injury risk.

Table 1 provides an integrated summary of practical recommendations for managing jet lag in athletes, combining expert-based clinical guidance with evidence-informed circadian principles [12,22,23]. These recommendations emphasize the role of sleep hygiene, strategic light exposure, appropriately timed physical activity, cautious use of napping, and sufficient recovery time before resuming intensive training. Particular attention is given to differences between eastward and westward travel, acknowledging the greater circadian challenge associated with phase advances. Overall, this figure highlights actionable strategies to mitigate circadian misalignment, reduce fatigue, and optimize recovery and performance during jet lag affected travel.

7. Conclusion and therapeutic perspectives

Sleep and physical activity are two essential pillars of mental health, sports performance, and recovery (Table 2). Regular physical activity combined with healthy sleep–wake behaviors represents an effective strategy for preventing and treating sleep disorders and promoting mental health [8]. However, individual rhythms and sport-specific constraints must be considered to optimize these benefits.

Knowledge regarding sleep–wake cycles, sleep homeostasis, napping, recovery, and circadian adaptation should be better integrated into professional sports environments. Athletes are not the only stakeholders: coaches, sports directors, strength and conditioning specialists, and competition organizers should also be trained in sleep optimization strategies to adapt training schedules, recovery periods, and competition planning to athletes’ biological and circadian constraints.

Finally, further research is needed to better define the intensity and duration thresholds of physical activity that maximize positive effects on sleep. Therapeutic perspectives include the development of personalized exercise programs tailored to individual needs, particularly for individuals suffering from sleep disorders or comorbid psychiatric conditions.

Use of artificial intelligence tools

The author, who is non-native English speaker, used ChatGPT (OpenAI, GPT-5.3) exclusively for language editing and assistance in figure design and formatting. No AI tool was used for data generation, analysis, or interpretation. All AI-assisted content was thoroughly reviewed and revised by the author, who verified its accuracy and ensured that it faithfully reflects the original data and scientific intent. The author takes full responsibility for all aspects of the manuscript.

Disclosure of interest

The author declares that he has no competing interest.

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