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Smartphone Blue Light Exposure, Sleep Quality, and Athletic Recovery in Athletes: A Narrative Review

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Abstract

Introduction: Sleep is essential for athletic recovery, training adaptation, hormonal regulation, and injury prevention. In athletes, poor sleep may reduce training readiness, physical and cognitive performance, and increase the risk of overload or injury. Evening smartphone use increases exposure to blue light, which may disturb circadian rhythm, suppress melatonin secretion, increase alertness, and worsen sleep quality.

Aim of the study: This review aimed to assess how evening smartphone blue light exposure may affect sleep quality, post-exercise recovery, training readiness, and sports performance in athletes.

Material and methods: A narrative review was conducted using PubMed, Scopus, Web of Science, and Google Scholar. Publications from 2015–2026 concerning blue light exposure, evening smartphone use, sleep quality, melatonin secretion, circadian rhythm, athletic recovery, injury risk, training readiness, and sports performance were analyzed.

Results: Evening blue light exposure may delay sleep onset, shorten total sleep time, reduce sleep efficiency, and disturb sleep architecture, including slow-wave sleep. These changes may impair muscle regeneration, hormonal balance, cognitive function, physical performance, and readiness for subsequent training sessions. Limiting smartphone use before bedtime, avoiding devices in bed, using night mode, and increasing morning bright light exposure may support better sleep, recovery, and training adaptation.

Conclusions: Reducing evening smartphone use may be a practical strategy to support sleep quality, athletic recovery, and sports performance. Sleep hygiene and proper management of blue light exposure should be considered part of training preparation, recovery strategies, and injury prevention in athletes.

Keywords: blue light; sleep quality; athletic recovery; sports performance; athletes; circadian rhythm

Introduction

Sleep is one of the key pillars of athletic recovery, training adaptation, and sports performance. For athletes, both sleep duration and sleep quality are essential for muscle repair, hormonal balance, nervous system recovery, cognitive function, and readiness for subsequent training sessions. When sleep is shortened or disrupted, the recovery process may be less effective, which can lead to greater fatigue, impaired concentration, poorer decision-making, reduced training quality, higher injury risk, and lower athletic performance [1,2].

In contemporary sport, recovery is influenced not only by training load, nutrition, and planned regeneration strategies, but also by everyday behavioral habits. One of the most common habits among athletes and physically active individuals is the use of smartphones in the evening and shortly before sleep. This behavior may expose athletes to blue light emitted by mobile screens at a time when the body should naturally prepare for rest. As a result, evening smartphone use may disturb circadian rhythm regulation, reduce sleep duration, worsen sleep quality, and limit sleep-dependent recovery [3–5].

Blue light emitted by smartphone screens, with a wavelength of approximately 450–495 nm, is particularly important for sleep regulation. This light stimulates melanopsin-containing retinal ganglion cells, which transmit signals to the suprachiasmatic nucleus (SCN), the central biological clock of the body. Evening exposure to blue light may suppress melatonin secretion, delay the circadian phase, prolong sleep latency, and reduce total sleep time and sleep efficiency [6–9]. From a sports perspective, these effects are important because even small, repeated disturbances in sleep may gradually reduce recovery efficiency and training readiness.

Previous research has shown that the use of light-emitting devices before bedtime can delay sleep onset, reduce evening sleepiness, and decrease alertness the following morning [6]. Similar findings were reported by Silvani et al., who indicated that blue light exposure may negatively affect sleep quality, well-being, cognitive function, and physical performance in young adults [7]. Zhong et al. also confirmed that regular screen use before sleep is associated with a greater risk of insufficient sleep duration and circadian rhythm disruption [5].

For athletes, impaired sleep may have consequences that go beyond tiredness or reduced comfort. Sleep is a key period for muscle protein synthesis, growth hormone secretion, glycogen restoration, and regulation of inflammatory and hormonal responses after exercise. Sleep deprivation may increase cortisol levels, reduce testosterone concentration, and impair the body's ability to recover effectively from training loads [1,10]. Moreover, sleep restriction has been shown to reduce myofibrillar protein synthesis, which may directly limit muscle repair and adaptation following exercise [10].

The impact of insufficient sleep on athletic performance is well documented. Sleep loss may impair strength, power, endurance, reaction time, technical skills, and decision-making, while also increasing perceived fatigue [11,12]. It may also increase the risk of injury and reduce readiness for subsequent training sessions. Importantly, Knufinke et al. demonstrated that reducing short-wavelength light exposure in the evening may improve sleep quality and support recovery in recreational athletes [13].

Although the relationship between digital device use and sleep has been widely studied, fewer publications have focused specifically on the role of smartphone-emitted blue light in athletic recovery. This issue is highly relevant for sports science and practice because evening smartphone use is a modifiable behavior. Understanding its impact may help athletes, coaches, and sports staff develop practical sleep hygiene strategies aimed at improving recovery, supporting training adaptation, and reducing the risk of overload and injury [13].

Aim of this Review

The aim of this review was to examine the relationship between evening smartphone blue light exposure, sleep quality, and athletic recovery. Particular attention was given to the effects of smartphone use before sleep on melatonin secretion, circadian rhythm regulation, sleep latency, total sleep time, and sleep efficiency.

This review also analyzed how sleep disturbances related to blue light exposure may influence key aspects of sports recovery, including muscle regeneration, hormonal balance, heart rate variability (HRV), training readiness, and preparation for subsequent exercise sessions. In addition, the review aimed to identify practical sleep hygiene recommendations and strategies for reducing evening blue light exposure in order to support recovery, training adaptation, and athletic performance.

Materials and Methods

This study was conducted as a narrative review focused on the relationship between evening smartphone blue light exposure, sleep quality, and recovery in athletes. The main aim was to summarize current evidence on how using mobile devices before sleep may affect sleep parameters and, as a result, training readiness, post-exercise recovery, and sports performance.

A literature search was carried out in PubMed, Scopus, Web of Science, and Google Scholar. The search strategy included combinations of the following terms: “blue light”, “smartphone”, “sleep quality”, “melatonin”, “circadian rhythm”, “sleep deprivation”, “athlete recovery”, “post-exercise recovery”, “training readiness”, “sports performance”, “screen exposure”, and “sleep hygiene”. Publications from 2015 to 2026 were considered if they were available in full text and written in English.

The review included experimental research, randomized controlled trials, systematic reviews, meta-analyses, and expert consensus papers. Sources were selected when they discussed the influence of blue light exposure, evening smartphone use, or circadian rhythm disruption on sleep quality, recovery after exercise, physical performance, cognitive functioning, or injury risk. Particular attention was given to research involving athletes, recreationally active

individuals, and young adults, as these groups frequently use smartphones in the evening and may be especially vulnerable to reduced sleep-dependent recovery.

Publications were excluded if they were not related to sleep, recovery, physical activity, or sports performance, focused on light exposure without reference to smartphones or mobile devices, or had limited methodological quality or insufficient scientific relevance.

Research Results

The reviewed literature suggests that evening exposure to blue light emitted by smartphones may negatively affect sleep quality and sleep-dependent recovery in athletes and physically active individuals. From a sports perspective, this is important because even small disturbances in sleep may reduce training readiness, delay recovery after exercise, and impair the quality of subsequent training sessions.

Mechanisms of Blue Light Influence on Circadian Rhythm and Sleep

Melatonin Suppression

One of the main mechanisms through which blue light affects sleep is the suppression of melatonin secretion. Melatonin plays an important role in regulating the sleep–wake cycle and preparing the body for night-time recovery. In athletes, this process is particularly relevant because proper sleep initiation supports physiological recovery after training.

Research has shown a dose–response relationship between light intensity and the degree of melatonin suppression. Exposure to blue light with a wavelength of approximately 470 nm at 40 lux for 1 hour was associated with about 46% melatonin suppression, while exposure at 100 lux increased this effect to approximately 65% [9,10]. Importantly, even low-intensity blue light may produce measurable physiological effects. Exposure to only 6 lux of blue light for 90 minutes was reported to suppress melatonin secretion in the majority of participants [9].

Chang et al. found that using a light-emitting eReader for 4 hours before bedtime reduced melatonin concentration by approximately 55% compared with reading a printed book [6]. This effect was most pronounced in the evening, and the onset of melatonin secretion, known

as dim light melatonin onset (DLMO), was delayed by an average of 1.5 hours [6]. For athletes, such a delay may be problematic, as later sleep onset can shorten the available recovery window between training sessions.

Delay of Circadian Rhythm Phase

Evening exposure to blue light may also delay the circadian rhythm phase. The use of light-emitting devices over several consecutive evenings has been shown to shift the biological rhythm by approximately 1–1.5 hours [2,6]. In practice, this means that athletes using smartphones late in the evening may fall asleep later and obtain less sleep before morning training, school, work, or competition-related duties.

Meyer et al. reported that even relatively low-intensity evening light, around 100 lux, may cause a meaningful delay in melatonin phase [2]. This effect appears to depend on both the duration and timing of exposure. The longer the screen exposure occurs before bedtime, the greater the potential disruption of the circadian rhythm. From a training perspective, repeated circadian delays may reduce sleep regularity, impair recovery efficiency, and negatively affect readiness for subsequent exercise sessions.

Increased Alertness and Reduced Sleepiness

Blue light may also exert a direct stimulating effect on the central nervous system. Individuals using smartphones or eReaders before bedtime often report lower evening sleepiness and greater alertness, which may make it more difficult to fall asleep [6]. In athletes, this effect may be particularly important because delayed sleep onset can shorten the recovery window between training sessions. Importantly, the stimulating effect may also persist into the following morning, contributing to greater fatigue, reduced concentration, and lower readiness for training or competition [6,7].

Impact of Blue Light Exposure on Sleep Parameters

Sleep Duration and Sleep Latency

Evening smartphone use is associated with prolonged sleep latency, shorter total sleep time, and reduced sleep efficiency. In the systematic review by Silvani et al., blue light exposure before bedtime was linked to prolonged sleep latency in 46% of the analyzed publications and

to a reduction in total sleep time by approximately 20–30 minutes [7]. From a sports perspective, even such moderate sleep loss may be relevant when it occurs repeatedly, especially during periods of intensive training.

Bourke et al. reported that each additional hour of daily screen use was associated with shorter sleep duration, with this relationship being stronger when devices were used in the evening or during the night [4]. Similarly, Hartley et al. described a dose–response relationship, showing that more than 2 hours of evening screen use significantly increased the risk of sleep deprivation [11]. For athletes, this may translate into reduced recovery quality, lower morning readiness, and poorer adaptation to training loads.

Sleep Quality

Blue light exposure may negatively affect sleep quality in both subjective and objective assessments. Randjelović et al. found that using smartphones without a blue light filter for 2 hours before bedtime was associated with significantly poorer Pittsburgh Sleep Quality Index (PSQI) scores compared with using smartphones in night mode [8]. In practice, poorer sleep quality may affect how rested an athlete feels the next day and may reduce the effectiveness of planned training sessions.

Meta-analyses also indicate that longer screen time is associated with a higher risk of poor sleep quality and more frequent sleep disturbances [3–5]. This is important for sports practice because sleep quality, not only sleep duration, influences recovery, concentration, reaction time, and physical performance.

Injury Risk

Insufficient sleep may also increase the risk of sports injuries. Athletes sleeping less than 8 hours per night appear to have a higher risk of injury than those who maintain adequate sleep duration [1,14]. This is important in practical coaching because sleep deficiency may impair concentration, reaction time, movement control, and decision-making.

Reduced concentration, slower reaction time, and poorer decision-making may increase the risk of technical errors, overload, and injury during training or competition [13]. For this reason, monitoring sleep habits and evening smartphone use may be useful not only for improving recovery, but also as part of injury prevention strategies in athletes.

Sleep Architecture

Polysomnographic research suggests that blue light exposure before bedtime may also alter sleep architecture. Ishizawa et al. reported a reduction in slow-wave sleep (N3), which is particularly important for physical recovery, as well as a shortening of REM sleep duration [12]. Since deep sleep plays a central role in tissue regeneration, hormonal regulation, and recovery processes, its reduction may limit the body's ability to recover effectively after physical effort. For athletes, this may be especially relevant during periods of high training load, when the demand for sleep-dependent recovery is increased.

Recovery and Physical Performance

Research involving athletes suggests that poor sleep quality can noticeably reduce the effectiveness of post-exercise recovery. In sport, sleep should be treated as one of the basic elements of regeneration, together with training load management, nutrition, hydration, and planned recovery strategies. When sleep is too short or disrupted, athletes may experience greater fatigue, lower readiness to train, and weaker physical and cognitive performance. In practice, even a well-designed training plan may be less effective if the athlete does not recover properly during sleep.

Fullagar et al. reported that sleep restriction may reduce muscle strength, endurance, reaction time, and technical skills in athletes [13]. Similar conclusions were presented in meta-analyses by Craven et al. and Kong et al., which showed that sleep loss may be associated with an average decrease of approximately 7% in physical performance, including strength, power, endurance, and technical control [22,23]. These findings are especially important in sports that require repeated high-intensity efforts, fast reactions, technical precision, and quick recovery between training sessions or competitions.

Rozman et al. also showed that intensive smartphone use in the evening may contribute to sleep debt and poorer morning well-being in athletes [17]. This may reduce readiness for the next training session and, over time, negatively affect sports performance, recovery quality, and tolerance to accumulated training load.

Hormonal and Muscular Recovery

Hormonal changes caused by insufficient sleep are also important for athletic recovery. Sleep restriction is associated with higher cortisol levels and lower concentrations of testosterone and growth hormone, which may weaken anabolic processes and muscle regeneration [1,15]. For athletes, this hormonal imbalance may limit the body's ability to repair muscle tissue and adapt to repeated training stimuli.

Saner et al. demonstrated that even short-term sleep restriction can significantly reduce myofibrillar protein synthesis, which is essential for muscle repair and adaptation after exercise [15]. Sleep deficiency may also increase inflammatory responses and reduce the body's ability to tolerate repeated training loads [24]. This means that poor sleep may not only delay recovery after a single workout, but also reduce long-term training adaptation.

Effectiveness of Interventions Reducing Blue Light Exposure

Several strategies have been proposed to reduce the negative effects of evening blue light exposure. Knufinke et al. showed that limiting exposure to short-wavelength light in the evening may improve sleep quality and reduce fatigue in recreational athletes [16]. This is relevant for sport practice because such strategies are simple, low-cost, and easy to include in daily recovery routines.

Current evidence suggests that blue light filters, night mode settings on smartphones, and reducing screen use before bedtime may improve sleep parameters and support recovery [8,16]. Teran et al. reported that night mode may be more effective than blue-light-blocking glasses in reducing melatonin suppression, although it does not fully remove the negative influence of evening device use [20]. Therefore, night mode should be seen as a helpful support, not as a complete solution.

The most consistent benefits seem to occur when electronic device use is limited 2–3 hours before bedtime. This approach has been associated with longer sleep duration, better morning alertness, and improved physical performance [16,21]. From a sports perspective, reducing evening smartphone use may be a practical and low-cost part of sleep hygiene, especially during periods of intensive training, competition, and accumulated fatigue.

Synthesis of Results

Overall, the reviewed literature suggests that smartphone blue light exposure may contribute to sleep disturbances and weaker post-exercise recovery. The main mechanisms include melatonin suppression, delayed circadian rhythm phase, and increased evening alertness [6,9,10].

In athletes, these changes may lead to shorter sleep duration, poorer sleep quality, impaired muscle recovery, hormonal disturbances, reduced training readiness, lower physical performance, and higher injury risk [1,13,15,22,23]. Limiting smartphone use in the evening, especially before bedtime, appears to be a simple and realistic strategy to support sleep quality, recovery, training adaptation, and the overall effectiveness of the training process [16,20,21,27].

Discussion

The findings of this review suggest that evening exposure to blue light emitted by smartphones may reduce sleep quality and weaken post-exercise recovery in athletes and physically active individuals. This issue is particularly relevant in sport, where recovery is a key factor determining training adaptation, readiness for subsequent sessions, and overall performance. Since mobile devices are commonly used shortly before bedtime, evening smartphone habits may become an underestimated factor contributing to circadian disruption, sleep debt, and reduced recovery efficiency [1,2].

The influence of blue light on sleep is mainly related to three mechanisms: suppression of melatonin secretion, delay of the circadian rhythm phase, and increased evening alertness [2,6,9,10]. These mechanisms often occur together and may lead to longer sleep latency, shorter total sleep time, and poorer sleep quality. From a training perspective, even small but repeated disturbances in sleep may be important, especially during periods of high training load, competition, travel, or accumulated fatigue.

Multifactorial Nature of Smartphone Influence on Sleep

An important conclusion from the reviewed literature is that the effect of smartphones on sleep should not be explained only by blue light exposure. Sleep disturbances associated with smartphone use are usually multifactorial and may also involve behavioral and cognitive mechanisms. Apart from the biological effects of screen light, emotional stimulation, social media use, stress related to viewed content, notifications, and keeping the device in the bedroom may also disturb sleep [3,4].

Smartphone use after getting into bed appears to be especially unfavorable because it may prolong sleep latency and reduce total sleep time [11]. For athletes, this is important because using the phone in bed may shorten the actual recovery window between training sessions. It may also disturb the natural transition from wakefulness to sleep, delaying the moment when the body begins to enter a restorative state. Over time, this may create a self-reinforcing pattern: difficulties with falling asleep encourage further smartphone use, while continued device use makes sleep onset even more difficult.

Moreover, the smartphone itself may act as a sleep-disrupting factor even when it is not actively used. Notifications, sounds, screen lighting, and the habit of checking the device can increase mental arousal during the night [3,4,11]. Therefore, the problem is not limited to the light emitted by the screen, but also includes the broader pattern of evening technology use. In sport practice, this means that sleep hygiene should include not only screen settings, but also behavioral rules, such as avoiding mobile devices in bed and keeping the phone outside the sleeping area.

Biological Mechanisms and Individual Variability

Melatonin suppression is one of the main mechanisms explaining how blue light affects sleep. Melatonin plays an important role in regulating circadian rhythm and preparing the body for night-time recovery. Evidence shows that even low-intensity blue light can reduce melatonin secretion, particularly in the evening [9,10]. For athletes, this may be relevant because delayed melatonin secretion can postpone sleep onset and reduce the time available for recovery after training.

Blue light exposure may also delay the circadian rhythm phase, shifting sleep onset to later hours. As a result, athletes who use smartphones intensively in the evening may fall asleep

later, sleep for a shorter time, and experience greater daytime sleepiness and fatigue [2,6]. This may reduce morning readiness, impair concentration during training, and negatively affect the quality of subsequent exercise sessions.

It is also important to note that sensitivity to light exposure differs between individuals. Chronotype, age, sex, genetic factors, previous sleep habits, and training schedule may influence how strongly a person responds to blue light [2]. In athletes, this means that the same evening exposure may have different consequences depending on individual characteristics and the timing of training. For this reason, sleep hygiene recommendations should be individualized rather than applied in a single universal way. Coaches and sports staff should consider evening smartphone use as a modifiable factor that may influence recovery, training adaptation, and injury prevention.

Impact on Recovery and Athletic Performance

The reviewed literature suggests that poor sleep quality can clearly weaken post-exercise recovery. In athletes, sleep should not be treated only as a period of rest, but as an important part of the training process. It supports muscle repair, hormonal regulation, nervous system recovery, and adaptation to repeated training loads [1,15,25,27]. Slow-wave sleep (SWS) is especially important, as it is linked to growth hormone secretion, tissue regeneration, and restoration of muscle structures after exercise.

Meta-analyses have shown that sleep deprivation may reduce physical performance by approximately 7%, affecting strength, power, endurance, and technical abilities [22,23]. Even short-term sleep restriction can slow reaction time, reduce concentration, increase perceived fatigue, and lower motivation to train. In practice, this may decrease the quality of training and competition performance, particularly in sports requiring repeated high-intensity efforts, quick decisions, and technical precision.

Sleep deficiency also affects hormonal balance. It may increase cortisol levels and reduce testosterone and growth hormone concentrations, which can limit post-exercise recovery [15,24]. Higher cortisol activity promotes catabolic processes, while lower anabolic hormone activity may impair muscle rebuilding. Saner et al. showed that even short-term sleep restriction significantly decreases myofibrillar protein synthesis, which is essential for muscle

repair after exercise [15]. This indicates that poor sleep may not only delay recovery after a single session, but may also weaken long-term adaptation during the training cycle.

Research involving athletes also suggests that intensive smartphone use in the evening may contribute to sleep debt, poorer morning well-being, and lower readiness to train [17]. Over time, this may increase the risk of overload, injury, and reduced effectiveness of the training process. This is particularly important during competition periods, training camps, travel, and phases of high training volume, when recovery demands are especially high.

Practical Implications for Athletes

From a practical point of view, evening smartphone use should be treated as a modifiable habit that may affect sleep quality, recovery, and training readiness. Athletes may benefit from reducing smartphone use 2–3 hours before bedtime, avoiding mobile devices in bed, and using night mode when evening screen use is necessary [14,16,20]. However, night mode should be considered only as an additional support, as it does not eliminate other factors that may disturb sleep, such as cognitive stimulation, notifications, or prolonged screen engagement [3,4,11].

Sleep hygiene education may be useful for athletes, coaches, strength and conditioning specialists, physiotherapists, and other members of sports staff, especially during periods of intensive training, competition, travel, or accumulated fatigue [1,14,21]. Simple routines, such as keeping the phone away from the bed, disabling notifications at night, and maintaining a regular sleep schedule, may help protect sleep quality and improve daily recovery [1,3,14].

Morning exposure to natural light may also support circadian rhythm regulation, improve daytime alertness, and help athletes maintain more regular sleep timing [2,21,25]. Therefore, managing evening smartphone use should be considered one practical element of recovery planning, alongside nutrition, hydration, training load monitoring, and other regeneration strategies [1,14,21]. In this context, monitoring screen habits may help coaches and sports staff support sleep-dependent recovery, training readiness, and performance, particularly during periods of high training load, competition, travel, and accumulated fatigue [1,14,21].

Effectiveness of Interventions Reducing Blue Light Exposure

An important part of the discussion is the practical value of strategies aimed at reducing evening blue light exposure. Current evidence suggests that the most effective approach is still limiting the use of electronic devices in the evening, especially during the last 2–3 hours before sleep [16,21,26]. This is a simple and low-cost strategy that can be easily included in daily recovery routines. For athletes, it may be particularly useful during intensive training periods, competition phases, training camps, and travel.

Night mode on smartphones may also reduce some of the biological effects of evening screen exposure. Teran et al. showed that night mode may be more effective than blue-light-blocking glasses in reducing melatonin suppression [20]. However, it should not be seen as a complete solution, because it does not eliminate other factors that disturb sleep, such as cognitive stimulation, notifications, or prolonged screen use. In sports practice, night mode may therefore be useful as an additional tool, but it should be combined with better evening habits, especially when optimal recovery before training or competition is needed.

Meta-analyses suggest that blue-light-blocking glasses do not significantly improve objective sleep parameters, despite being commonly promoted as a sleep-supporting method [18,19]. This is important for coaches and sports staff, because recovery strategies should be based on real effectiveness rather than popularity or marketing claims.

The best results seem to come from a combined approach. Reducing screen exposure in the evening, together with increasing morning exposure to bright light, may support circadian rhythm regulation, improve daytime alertness, and help athletes fall asleep earlier in the evening [21,25]. This may be especially valuable during demanding training microcycles, congested competition schedules, and periods of accumulated fatigue, when even small improvements in sleep quality can support recovery, training adaptation, and readiness for the next exercise session.

Potential Benefits of Blue Light

It is also worth emphasizing that blue light is not always harmful. During the day, exposure to bright light, including blue-enriched light, may improve alertness, concentration, reaction speed, and cognitive performance [7]. These effects can be useful in sport, particularly in

disciplines that require quick decision-making, sustained attention, tactical awareness, and fast reactions.

Therefore, the aim should not be to eliminate blue light completely, but to manage the timing of exposure more consciously. From both health and sports performance perspectives, the most reasonable approach is to promote exposure to natural light in the morning and during the day, while reducing screen-related blue light in the evening [2,21,25]. In practice, athletes and coaches may treat light exposure as one element of recovery management, alongside sleep scheduling, training load monitoring, nutrition, hydration, and other regeneration strategies.

Conclusion

Evening exposure to blue light emitted by smartphones may negatively affect sleep quality mainly through three mechanisms: suppression of melatonin secretion, delay of the circadian rhythm phase, and increased evening alertness [2,6,9,10]. These effects can contribute to longer sleep latency, shorter total sleep time, and poorer sleep quality and architecture, including a reduction in slow-wave sleep, which is especially important for physical recovery [6,7,12].

However, the influence of smartphones on sleep is not limited to blue light alone. Behavioral factors, such as social media use, cognitive stimulation, nighttime notifications, and keeping a smartphone in the bedroom, may also disturb sleep [3,4]. Using a smartphone after getting into bed appears to be particularly unfavorable, as it is associated with a higher risk of sleep deprivation [11].

For athletes, these findings are especially relevant because sleep is a key part of muscle recovery, hormonal balance, nervous system regeneration, and adaptation to training loads. Sleep deficiency may reduce physical performance, impair cognitive function, increase injury risk, lower training readiness, and weaken anabolic processes [1,13,15,22,23,26]. Hormonal disturbances, including increased cortisol levels and reduced testosterone and growth hormone concentrations, may further limit post-exercise recovery [15,24,27].

The most practical approach is to reduce smartphone use 2–3 hours before bedtime, avoid using devices in bed, and activate night mode when evening screen use is unavoidable [16,20,21]. Morning exposure to bright light may also support circadian rhythm synchronization and improve daily functioning [21,25]. Overall, managing evening smartphone use and blue light exposure should be considered a simple but important element of sleep hygiene, recovery strategies, training readiness, performance optimization, and injury prevention in athletes. Coaches and sports staff may also use basic sleep hygiene recommendations in daily recovery planning, especially during periods of intensive training, competition, travel, and accumulated fatigue.

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