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SLEEP AND PHYSICAL RECOVERY METHODS IN SPORT: A NARRATIVE REVIEW

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ABSTRACT

Recovery is a fundamental component of athletic training and performance. Appropriate recovery strategies support physiological adaptation, reduce fatigue, and decrease the risk of injury. Among the various recovery approaches used in sport, sleep and physical recovery methods are the most commonly applied by athletes and coaches. The aim of this narrative review was to evaluate the role of sleep and selected physical recovery methods in post-exercise recovery. A literature search was conducted using electronic databases, including PubMed and Google Scholar. Original studies, systematic reviews, meta-analyses, and narrative reviews related to sleep, cold-water immersion, massage, stretching, and foam rolling were analyzed. Current evidence indicates that sleep is the most important recovery factor, as it directly influences hormonal regulation, immune function, glycogen restoration, protein synthesis, cognitive performance, and overall adaptation to training. Adequate sleep has been associated with improved reaction time, endurance, concentration, and reduced injury risk. In contrast, physical recovery methods appear to be effective mainly in reducing delayed onset muscle soreness and perceived fatigue, while their influence on physiological recovery mechanisms remains limited. Methods such as cold-water immersion, massage, stretching, and foam rolling may improve subjective recovery and readiness for subsequent exercise sessions. The findings suggest that sleep should be prioritized as the primary recovery strategy, whereas physical recovery methods should be considered complementary interventions. A combined recovery approach may provide the greatest benefits for athletic performance and long-term adaptation.

KEYWORDS

Sleep; Recovery; Sport Performance; Cold-Water Immersion; Massage; Foam Rolling

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1. Introduction

Recovery is a fundamental component of athletic training and performance. It enables the restoration of physiological homeostasis, repair of exercise-induced tissue damage, replenishment of energy stores, and adaptation to training stimuli. Adequate recovery is essential for maintaining performance, reducing fatigue, and minimizing the risk of injury. Conversely, insufficient recovery may result in decreased physical and cognitive performance, increased susceptibility to injury, and the development of overtraining syndrome (Kellmann et al., 2018; Murphy et al., 2024).

Among the various recovery strategies used in sport, sleep is widely recognized as the most important. Sleep supports numerous biological processes that are essential for recovery, including hormonal regulation, immune function, metabolic restoration, protein synthesis, and neural regeneration (Besedovsky et al., 2012; Morselli et al., 2012; Fullagar et al., 2015). During sleep, growth hormone secretion increases, glycogen stores are replenished, and physiological systems responsible for adaptation and tissue repair become highly active. These processes contribute directly to athletic performance and long-term training adaptation (Cook & Charest, 2023; Walsh et al., 2021).

Research consistently demonstrates that adequate sleep positively influences athletic performance. Athletes who obtain sufficient sleep generally exhibit improved reaction time, concentration, decision-making, accuracy, endurance, and emotional regulation (Gupta et al., 2022; Ochoa-Lácar et al., 2022). In contrast, sleep deprivation has been associated with impaired cognitive functioning, increased fatigue, reduced motivation, and decreased physical performance (Fullagar et al., 2015; Gupta et al., 2022). Furthermore, poor sleep quality and insufficient sleep duration have been linked to an elevated risk of musculoskeletal injuries and prolonged recovery times (Huang & Ihm, 2021; Knufinke et al., 2018).

Despite its importance, many athletes experience sleep-related problems. Factors such as intensive training schedules, competition stress, frequent travel, and irregular daily routines may negatively affect sleep

quality and duration. Consequently, athletes often fail to achieve optimal sleep, potentially limiting recovery effectiveness and performance outcomes (Doherty et al., 2021; Walsh et al., 2021).

In addition to sleep, athletes commonly utilize physical recovery methods to support post-exercise regeneration. Popular strategies include cold-water immersion, massage, stretching, and foam rolling. These methods are frequently used to reduce muscle soreness, alleviate perceived fatigue, and improve readiness for subsequent training sessions. Although many athletes report positive subjective effects, the scientific evidence regarding their effectiveness remains mixed, particularly with respect to physiological recovery mechanisms (Dupuy et al., 2018).

Cold-water immersion is commonly applied to reduce exercise-induced muscle soreness and inflammation, especially following high-intensity training sessions (Hohenauer et al., 2015; Leeder et al., 2012). Massage is frequently used to promote relaxation and reduce discomfort, whereas stretching and foam rolling are often incorporated into recovery routines to maintain flexibility and decrease muscle stiffness (Davis et al., 2020; Poppendieck et al., 2016; Wilke et al., 2020). While these methods may improve subjective perceptions of recovery, their effects on physiological adaptation and performance enhancement appear less pronounced than those associated with adequate sleep (Dupuy et al., 2018).

Given the widespread use of both sleep-based and physical recovery strategies, understanding their relative effectiveness is important for athletes, coaches, and sports practitioners. Evidence-based recovery practices may contribute to improved performance, enhanced well-being, and reduced injury risk across different sporting disciplines.

Therefore, the aim of this narrative review was to evaluate the role of sleep and selected physical recovery methods in post-exercise recovery and athletic performance.

2. Materials and Methods

This study was conducted as a narrative review of the scientific literature concerning sleep and selected physical recovery methods in sport. The review aimed to identify and summarize current evidence regarding the effectiveness of sleep, cold-water immersion, massage, stretching, and foam rolling in post-exercise recovery and athletic performance.

A literature search was performed using electronic databases, including PubMed and Google Scholar. Relevant publications were identified using combinations of the following keywords: “sleep,” “sleep quality,” “sport recovery,” “athlete recovery,” “muscle recovery,” “cold-water immersion,” “cryotherapy,” “massage,” “stretching,” “foam rolling,” and “sport performance.”

The search focused primarily on articles published between 2018 and 2025 to ensure that the review reflected current scientific knowledge. However, several earlier publications were also included when they were considered fundamental to understanding the physiological mechanisms of recovery or represented highly cited landmark studies in the field.

The inclusion criteria comprised: (1) original research articles, (2) systematic reviews and meta-analyses, (3) narrative reviews, (4) studies involving human participants, and (5) publications written in English. Studies examining the relationship between sleep, physical recovery methods, recovery outcomes, and athletic performance were considered eligible for inclusion.

The exclusion criteria included: (1) studies involving animal models, (2) publications not available in English, (3) conference abstracts without full-text availability, and (4) studies unrelated to sport performance or post-exercise recovery.

The identified studies were reviewed and analyzed qualitatively. Particular attention was given to the reported effects of sleep and physical recovery interventions on physiological recovery, muscle soreness, fatigue, injury risk, cognitive performance, and athletic performance outcomes. The findings were subsequently grouped into thematic sections addressing sleep and physical recovery methods.

As a narrative review, this study did not follow a formal systematic review protocol and no quantitative meta-analysis was performed. Therefore, the findings should be interpreted as a qualitative synthesis of the available scientific evidence.

3. Results

3.1. Sleep and Recovery

Sleep is widely recognized as the most important recovery factor in sport because it directly influences the physiological and psychological processes responsible for adaptation and performance. Adequate sleep enables the restoration of homeostasis, repair of exercise-induced tissue damage, replenishment of energy stores, and recovery of the nervous system (Besedovsky et al., 2012; Fullagar et al., 2015).

Several biological mechanisms contribute to the recovery-promoting effects of sleep. During sleep, particularly during deep sleep stages, growth hormone secretion increases, supporting muscle repair, protein synthesis, and tissue regeneration. Sleep also contributes to glycogen restoration, metabolic regulation, and proper immune system functioning, all of which are essential for maintaining athletic performance and facilitating adaptation to training loads (Morselli et al., 2012; Cook & Charest, 2023).

A substantial body of evidence indicates that sufficient sleep positively affects athletic performance. Athletes who obtain adequate sleep generally demonstrate improved reaction time, concentration, decision-making, accuracy, endurance, and emotional regulation. These effects are particularly important in sports that require rapid information processing and precise motor execution (Gupta et al., 2022; Ochoa-Lácar et al., 2022).

In contrast, sleep deprivation negatively affects both physical and cognitive performance. Insufficient sleep has been associated with increased fatigue, reduced motivation, impaired reaction time, decreased endurance capacity, and lower training quality. Chronic sleep restriction may also limit recovery and adaptation processes, potentially reducing the effectiveness of training programs (Fullagar et al., 2015; Gupta et al., 2022).

Sleep quality appears to be equally important as sleep duration. Fragmented sleep and frequent awakenings may reduce time spent in restorative sleep stages, thereby impairing recovery processes. Consequently, both sleep quantity and quality should be considered when evaluating athlete recovery status (Doherty et al., 2021).

Research has also demonstrated a significant relationship between sleep and injury risk. Athletes who consistently fail to achieve sufficient sleep are more likely to experience musculoskeletal injuries and prolonged recovery periods. Adequate sleep therefore plays an important role not only in performance enhancement but also in injury prevention and long-term athlete health (Huang & Ihm, 2021; Knufinke et al., 2018).

Despite its importance, sleep disturbances are common among athletes. Intensive training schedules, competition-related stress, frequent travel, and irregular daily routines may negatively affect sleep quality and duration. These factors can create a cycle in which poor sleep impairs recovery, while inadequate recovery further disrupts sleep patterns (Walsh et al., 2021).

Overall, current evidence consistently identifies sleep as the most effective recovery strategy available to athletes. Unlike other recovery methods, sleep directly influences the primary physiological and neurological mechanisms responsible for recovery, adaptation, and performance. Therefore, it should be considered the foundation of any evidence-based recovery program.

3.2. Physical Recovery Methods

In addition to sleep, athletes frequently use various physical recovery methods to support post-exercise regeneration. These interventions are widely applied in both recreational and professional sport because they are relatively easy to implement and often provide immediate subjective benefits, including reduced muscle soreness and improved readiness for subsequent training sessions. However, unlike sleep, physical recovery methods generally do not directly influence the primary physiological mechanisms responsible for adaptation and recovery. Instead, their effects are mainly associated with reductions in perceived fatigue and discomfort (Dupuy et al., 2018).

3.2.1. Cold-Water Immersion

Cold-water immersion (CWI) is one of the most commonly used recovery strategies in sport. This method involves exposing the body to cold water following exercise, typically at temperatures ranging from 10°C to 15°C. The proposed mechanisms include vasoconstriction, reduced tissue temperature, and decreased inflammatory responses (Hohenauer et al., 2015).

Several studies have demonstrated that CWI may effectively reduce delayed onset muscle soreness (DOMS) and improve perceived recovery following intense exercise (Das et al., 2025; Leeder et al., 2012). These benefits appear particularly relevant after competitions or periods of high training load. However,

evidence regarding the long-term effects of CWI remains inconclusive. Some authors have suggested that frequent use of cold exposure may attenuate certain physiological adaptations, particularly those associated with strength and hypertrophy training (Dupuy et al., 2018). Therefore, while CWI may be useful for short-term recovery, its routine application should be carefully considered.

3.2.2. Massage

Massage is widely used in high-performance sport as a recovery intervention aimed at reducing muscle tension, promoting relaxation, and alleviating soreness. Athletes frequently report positive subjective responses following massage treatment, including improved comfort and a greater sense of recovery (Poppendieck et al., 2016).

Despite its popularity, the physiological effects of massage appear relatively modest. Current evidence suggests that massage may contribute to reductions in perceived muscle soreness and improve psychological well-being, although its direct impact on muscle recovery and performance restoration remains limited (Davis et al., 2020). Consequently, massage should be viewed primarily as a strategy for improving subjective recovery rather than accelerating physiological regeneration.

3.2.3. Stretching

Stretching is commonly incorporated into post-exercise recovery routines with the aim of maintaining flexibility, reducing muscle stiffness, and preserving range of motion. Static stretching is particularly popular among athletes following training and competition.

Although stretching may improve flexibility and mobility, current evidence does not strongly support its effectiveness in reducing muscle soreness or accelerating recovery processes. The available literature indicates that stretching has minimal influence on physiological recovery and may provide only limited benefits beyond maintaining joint mobility and movement quality (Behm et al., 2016). Nevertheless, stretching may remain a useful component of comprehensive training programs due to its role in flexibility maintenance.

3.2.4. Foam Rolling

Foam rolling has become increasingly popular as a form of self-myofascial release. This technique involves applying pressure to soft tissues using a cylindrical foam roller, with the aim of reducing muscle stiffness and improving mobility.

Research suggests that foam rolling may reduce muscle soreness, improve range of motion, and enhance perceived recovery following exercise (Skinner et al., 2020; Wilke et al., 2020). Some studies have also reported short-term improvements in performance when foam rolling is performed between training sessions (Wiewelhove et al., 2019). However, as with other physical recovery methods, the observed benefits appear to be largely subjective and do not consistently translate into substantial physiological recovery improvements.

Summary of Physical Recovery Methods

Overall, physical recovery methods appear to be most effective in reducing muscle soreness, perceived fatigue, and discomfort associated with exercise. While these interventions may improve athletes' readiness to train and compete, their influence on the underlying biological mechanisms responsible for recovery remains limited. Consequently, physical recovery methods should be regarded as complementary tools that support recovery rather than replace fundamental strategies such as adequate sleep (Dupuy et al., 2018).

Table 1. Comparison of Sleep and Physical Recovery Methods Source

Recovery strategy	Main mechanism	Primary benefits	Strength of evidence
Sleep	Physiological and neurological regeneration	Performance, adaptation, injury prevention	High
Cold-water immersion	Reduced inflammation and soreness	Reduced DOMS	Moderate
Massage	Relaxation and soreness reduction	Improved perceived recovery	Moderate
Stretching	Flexibility maintenance	Mobility preservation	Low to moderate
Foam rolling	Self-myofascial release	Reduced stiffness and soreness	Moderate

Source: Authors' own elaboration based on reviewed literature.

4. Discussion

The aim of this narrative review was to evaluate the role of sleep and selected physical recovery methods in post-exercise recovery and athletic performance. Based on the analyzed literature, sleep appears to be the most important and evidence-based recovery strategy available to athletes. In contrast, physical recovery methods such as cold-water immersion, massage, stretching, and foam rolling mainly provide supportive benefits by reducing muscle soreness and perceived fatigue.

The findings of this review are consistent with previous studies emphasizing the fundamental role of sleep in recovery and adaptation processes. Sleep directly influences physiological mechanisms responsible for muscle repair, hormonal regulation, immune function, energy restoration, and neural recovery (Besedovsky et al., 2012; Morselli et al., 2012; Walsh et al., 2021). Unlike most physical recovery interventions, sleep affects both physical and cognitive aspects of performance, including reaction time, concentration, decision-making, and emotional regulation (Gupta et al., 2022; Ochoa-Lácar et al., 2022).

An important observation emerging from the reviewed literature is that sleep quality may be as important as sleep duration. Athletes who experience fragmented or poor-quality sleep may demonstrate impaired recovery despite obtaining an apparently sufficient number of sleeping hours. Therefore, recovery strategies should focus not only on increasing sleep duration but also on improving overall sleep quality and sleep hygiene practices (Doherty et al., 2021; Walsh et al., 2021).

The reviewed evidence also highlights the association between sleep and injury prevention. Insufficient sleep has been linked to an increased risk of musculoskeletal injuries and prolonged recovery periods. This relationship emphasizes that sleep should not be viewed solely as a performance-enhancing factor but also as an important component of athlete health protection and long-term career sustainability (Huang & Ihm, 2021; Knufinke et al., 2018).

In contrast, physical recovery methods demonstrated more limited effects on physiological recovery processes. Cold-water immersion was found to be effective in reducing delayed onset muscle soreness and improving subjective recovery, particularly after intense exercise. However, concerns have been raised regarding its potential impact on long-term training adaptations when used excessively (Dupuy et al., 2018; Das et al., 2025). Similarly, massage, stretching, and foam rolling appear to provide benefits primarily through reductions in perceived soreness and improvements in comfort rather than through substantial physiological recovery enhancement (Davis et al., 2020; Wilke et al., 2020).

From a practical perspective, the findings of this review suggest that athletes and coaches should prioritize sleep as the foundation of recovery programs. Regular sleep schedules, appropriate sleep environments, and education regarding sleep hygiene may provide greater benefits than relying exclusively on physical recovery interventions. Physical recovery methods may still be valuable as complementary tools, particularly during periods of intensive training or competition when reductions in soreness and fatigue are desirable.

Several limitations of this review should be acknowledged. First, this study was conducted as a narrative review and therefore did not follow a systematic review protocol. Consequently, study selection may be subject to selection bias. Second, the included studies differed considerably in terms of participant characteristics, sporting disciplines, intervention protocols, and outcome measures, limiting direct comparisons between studies. Finally, much of the available evidence regarding physical recovery methods focuses on short-term outcomes, whereas long-term effects remain insufficiently investigated.

Future research should focus on standardized recovery protocols and long-term evaluations of recovery strategies across different sports and athlete populations. Additional studies investigating the interaction between sleep quality, training load, and recovery outcomes may further improve evidence-based recommendations for athletes and coaches.

Overall, the available evidence supports the view that sleep should remain the primary recovery strategy in sport, whereas physical recovery methods should be considered complementary interventions that may enhance subjective recovery and training readiness.

5. Conclusions

Sleep is the most important and effective recovery strategy in sport, as it directly influences the physiological and cognitive processes responsible for adaptation, performance, and overall athlete well-being. Adequate sleep supports muscle regeneration, hormonal balance, immune function, energy restoration, and cognitive performance, making it essential for optimal athletic development and long-term health.

Physical recovery methods, including cold-water immersion, massage, stretching, and foam rolling, may contribute to reductions in muscle soreness and perceived fatigue. However, their effects on the fundamental physiological mechanisms of recovery appear to be less pronounced than those associated with adequate sleep.

Based on the available evidence, athletes and coaches should prioritize sleep as the foundation of recovery programs. Physical recovery interventions may serve as useful complementary strategies, particularly when the goal is to improve comfort, reduce soreness, and enhance readiness for subsequent training sessions. A comprehensive recovery approach that combines adequate sleep with selected physical recovery methods may provide the greatest benefits for athletic performance and long-term adaptation.

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