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REVIEW - META-ANALYSIS

Causes of sleep deprivation in competative athletes: A scoping review

Causes de la privation de sommeil chez les athlètes de competition: étude de la portée

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Short-term deprivation ;
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Scoping review

Summary
Purpose. — Inadequate sleep has a negative impact on the psychological and physiological health of elite athletes. Studies have shown a correlation exists between sleep deprivation and a drop in performance. Despite rising interest in sleep science, current research focus is on outcome and the cause of sleep deprivation is a secondary consideration. This scoping review aims to identify themes in peer-reviewed studies that are related to the possible causation of sleep deprivation in competitive athletes.
Method. — A scoping review was conducted using the PRISMA-ScR guideline. Three databases were used to research for the literature PubMed, Medline and EBSCO.
Results. — After applying inclusion and exclusion criteria 16 peer-reviewed studies were identified. The studies were categorised into two sub-categories of short- and long-term causes of sleep deprivation. Five themes were identified: travel, night performance, prior, during and following competition and concussion.
Conclusion. — The findings of this scoping review identified a number a short and long-term causes of sleep deprivation. The causes of the short-term causes can be addressed by implementing some simple interventions such as napping, relaxation techniques and sleep hygiene could aid an athlete performance. However, the long-term causes were linked to concussion, any intervention would need to be studied in greater detail and is beyond the remit of this scoping review.

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MOTS CLÉS
Privation de sommeil ;
Privation à court terme ;
Habitudes de sommeil ;
Étude de portée

Résumé
Objectif. — Un sommeil insuffisant a un impact négatif sur la santé psychologique et physiologique des athlètes d'élite. Des études ont montré qu'il existe une corrélation entre la privation de sommeil et une baisse des performances. Malgré l'intérêt croissant pour la science du sommeil, la recherche actuelle se concentre sur les résultats et la cause de la privation de sommeil est une considération secondaire. La présente étude de portée vise à identifier les thèmes des études évaluées par des pairs qui sont liés à la cause possible de la privation de sommeil chez les athlètes de compétition.
Méthode. — Une étude de portée a été effectuée selon les règles PRISMA-ScR. Trois bases de données ont été utilisées pour la recherche de la littérature : PubMed, Medline et EBSCO.
Résultats. — Après application des critères d'inclusion et d'exclusion, 16 études évaluées par des pairs ont été identifiées. Les études ont été classées en deux sous-catégories de causes à court et à long terme de la privation de sommeil. Cinq thèmes ont été identifiés: déplacement, performance nocturne, avant, pendant et après compétition et commotion cérébrale.
Conclusion. — Les résultats de cette étude de portée ont identifié un certain nombre de causes à court et à long terme de la privation de sommeil. Les causes à court terme peuvent être traitées en mettant en œuvre des interventions simples telles que la sieste, les techniques de relaxation et l'hygiène du sommeil qui pourraient aider les performances d'un athlète. Cependant, les causes à long terme étant liées à une commotion cérébrale, toute intervention nécessiterait d'être étudiée plus en détail et dépasse le cadre de cette étude de portée.

1. Introduction

Sleep deprivation is a general term referring to a reduction in the usual quantity and/or quality of sleep [1]. Sleep is vital for human survival and lack of it can lead to serious physical and mental health issues. Sleep-deprived individuals can be judgement impaired, accident-prone and suffer from poor memory [2].

Research has shown that staying awake for 20 hours causes reduced hand-to-eye coordination that can be compared to having a blood alcohol content of 0.1% [3—5]. Worldwide, inadequate sleep has been associated with various health related issues and is considered an under-reported and unrecognised public health epidemic [6]. In the US for example, insufficient sleep has been associated with 7 of 15 leading causes of death including hypertension, cardiovascular disease, accidents, and septicaemia [7].

In a sporting context, sleep has been identified as an essential component of an effective training regime [8]. Despite this recognition, elite athlete populations have been shown to suffer from lower quality and quantity of sleep when compared to the general population [9,10]. Even short-term sleep deficits have been found to negatively affect vision, concertation, and reaction time [2]. A study conducted on tennis players showed that sleep loss can cause a 53% decrease in accuracy [11]. Similarly, sleep deprivation in runners has led to reduced sprint performance by 2.78 ± 0.17 s [12] and sleep deprived volleyball players have been found to have higher levels of fatigue than runners [13].

To ascertain a better understanding of the impact of sleep deprivation on performance Chandrasekaran, Fernandes and Davis [8] conducted a scoping review on competitive athletes. This scoping review identified the impact sleep deprivation had on 3 physiological systems: cardiorespiratory, neural, and endocrine systems. Chandrasekaran, Fernandes and Davis [8] noted that sleep deficiency effected the cardiorespiratory system by altering gaseous exchange and reduced cardiac recovery time. They also summarised neurological fatigue, brought about by a lack of sleep, caused reduced reaction time, focus, concentration, and poor motor control. The final summation of their scoping was that sleep disturbances had an impact on the function of the endocrine system resulting in a delay in the bodies healing process and reducing athletes' ability to cope with stress [8].

As current research infers that there is a correlation between sleep deprivation and reduced performance, a natural progression would be to look at the possible causes of sleep deprivation. Therefore, the aim of the current study is to utilise a scoping review and compose a list of possible causes of sleep deprivation. The rationale being that understanding the causes of sleep disturbances will enable coaches and athletes to devise coping mechanisms with the aim to enhance athletic performance [14].

2. Methods

This scoping review was conducted using a PRISMA Extension for Scoping Reviews. The PRISMA-ScR (Preferred Reporting Items for Systematic reviews and Meta-Analyses extension for Scoping Reviews) guideline were followed according to Tricco et al. [15]. This scoping review included 5 phases (see Fig. 1). Phase 1, identification, included a search of chosen electronic databases, phase 2 was the first screening of studies and excluding duplicates, phase 3 a review of full text and final eligibility, and phase 4 included studies.

2.1. Identification

Three electronic databases (PubMed, Medline, EBSCO) were searched between 2015 and 2022 using a combination of the following keywords in the titles and abstracts: athletic, runners, athlete(s), elite, athlete's, sport(s), players, and sleep. The result of 1324 was included in the next phase.

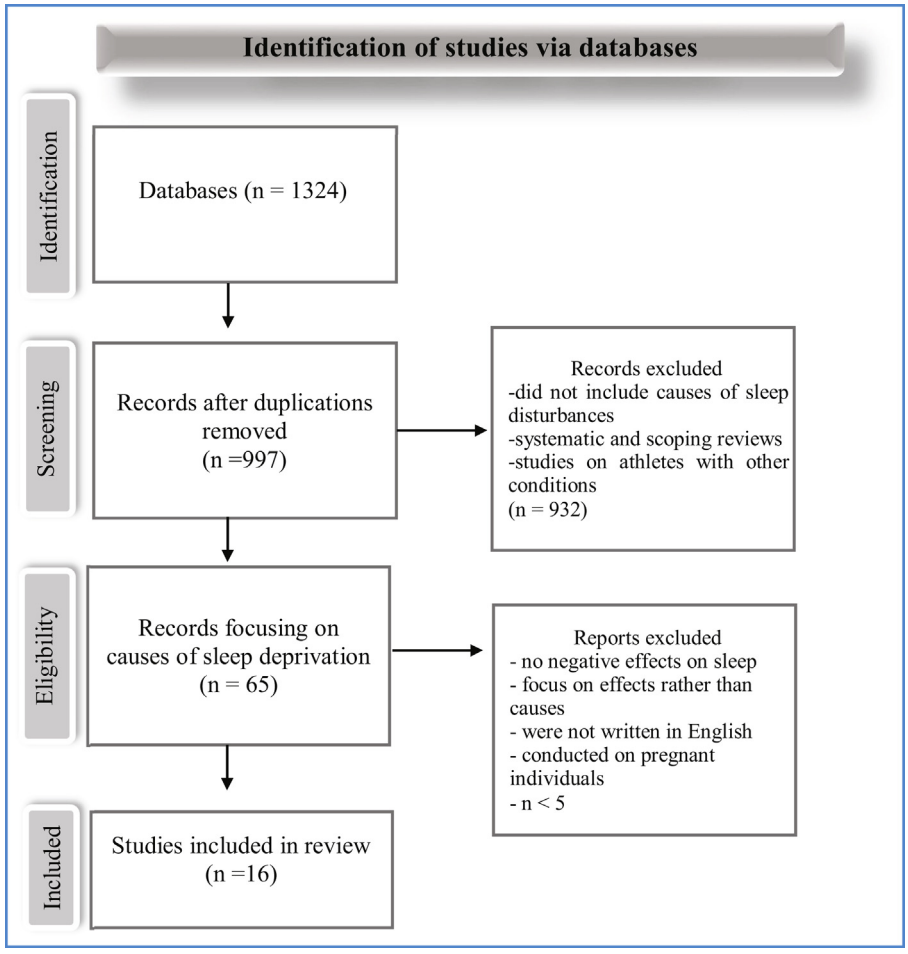

Figure 1 Flow diagram of the screening process. From Tricco et al. [15].

2.2. Screening

The 1324 studies were exported into EndNote and duplicates were removed. Titles of the remaining 997 studies were screened and an exclusion criteria applied. Titles which did not include potential causes of sleep disturbances were not included in the eligibility phase. Some of the excluded studies focused on the effects of sleep, analysed positive effects on sleep, sleep interventions, systematic reviews, investigated the prevalence of sleep, or researched athletes with other conditions. 65 studies were chosen to progress to phase 3 the eligibility phase (Fig. 1).

2.3. Eligibility

Phase 3 included scanning titles and abstracts applying the following criteria: (1) studies must be written in English, (2) research must be conducted on athletes, (3) must include causes of negative effect on sleep in participants, (4) must be published between January 2015 and April 2022, (5) cannot be a scoping review, literature review or systematic review, (6) was published in a peer-reviewed journal. Qualitative, quantitative, and mixed-method studies were included.

2.4. Included

Based on the title and the abstract, studies were excluded due to lack of information liked to causes of sleep deprivation, did not discuss the effects of sleep loss. The remaining 16 were considered eligible for this review and are included in Table 1.

3. Results

The final sixteen studies contained a varied cross section of athlete from a variety of sports and levels several of the studies had participants form multiple sports. These sports included: soccer/football (6 studies), rugby (4 studies), running (3 studies), hockey 1 (study), swimming 1 (study), cricket 1 (study), basketball 1 (study), triathlon 1 (study). The participants competitive level also varied with four of the studies containing amateur, 11 being professional and one which did not state the level participant level.

The themes from the scoping review were categorised into categories: long- and short-term causes of sleep deprivation. Each category was split into sub-themes:

- short-term effects of sleep deprivation:

Table 1 Studies included in the review.

Author	Aim	Sport	Level of performance	Design/Methods	Long-/short-term deprivation	Findings
Aloulou et al., 2019	To investigate the effects of night-time (21:00 hours) high-intensity, intermittent training on sleep structure	Running	Well-trained	Familiarization session and two experimental conditions: a simulated trail-running exercise (TRAIL) and no exercise during the day (REST)/in laboratory setting	Short-term	Late-night training increased HR and body core temperature during sleep, increased light sleep and decreased REM sleep
Biggins et al., 2022	To determine whether travel across 7 time zones has a significant impact on sleep duration and quality	Soccer	Elite	Not stated/daily monitoring via actigraphy and subjective sleep	Short-term	Sleep duration was significantly decreased pre-competition due to jet lag; female showed greater pre-sleep tension-anxiety
Blake et al., 2019	To determine the effects of concussion history on sleep disturbances	Team sports	Club/Varsity	Not stated/questionnaire	Long-term	Concussion history caused: fatigue (32%), sleeping too little (27%), restlessness (24%), difficulty falling asleep (24%), and difficulty staying asleep (13%)
Bliznak et al., 2018	To examine whether a history of concussion is a risk factor of poor sleep	(Not stated)	NCAA Division-I student athletes	Not stated/self-report; Insomnia Severity Index and The Pittsburgh Sleep Quality Index	Long-term	History of concussion was associated with an increased risk of moderate-severe insomnia ($P = 0.006$)
Brandenburg & Gaetz, 2015	To examine the effect of travel and sleep environment on the quantity and quality of sleep in athletes.	Hockey	Elite	Not stated/motion sensor and heart rate monitor	Short-term	Sleeping on the bus decreased sleep duration and increased daytime sleepiness
Caia et al., 2022	To investigate the association between caffeine intake and sleep on the night of competition	Rugby	Professional	A case study/differences in sleep across the 3 nights were examined using linear mixed models	Short-term	Night of competition: later going sleep and reduced duration of sleep compared to night before or after competition
Chennaoui et al., 2016	Evaluation of sleep indicators based on the outcomes of seven-day competition	Swimming	Professional, high-level	Not stated/collection of saliva samples, actigraphy measurements and the self- reported sleep diaries	Short-term	The stress of the competition potentially trigger a negative mood profile and sleep disturbance which was linked to responses of biomarkers (cortisol, sAA, and CgA)
Costa et al., 2019	To analyse whether exercise training conducted at night disturbs sleep	Soccer	High-level	Longitudinal study/monitored by actigraphy and heart-rate (HR) monitors	Short-term	Exercise training conducted at night shown to disturb sleep quality and quantity.

Table 1 (*Continued*)

Author	Aim	Sport	Level of performance	Design/Methods	Long-/short-term deprivation	Findings
Driller, & Cupules, 2018	To examine sleep prior to and following competition	Rugby	Professional	Not stated/sleep monitored by the actigraph SBV2 Readiband™, Fatigue Science, Honolulu, USA	Short-term	Large reduction of total sleep Prior to competition and affected sleep following the event
Fox et al., 2020	To determine whether contextual factors including game location, game outcome, and score-line margin influence subsequent nightly sleep duration	Basketball	Semi-professional	Observational study/wrist-worn activity monitors and sleep diaries	Short-term	Later sleep onset following away games, losses, and unbalanced games.
Fullagar et al., 2016	To examine the subjective sleep and recovery responses of elite footballers across training days and both day and night matches	Football	Elite	Observational study/questionnaire	Short-term	Significantly reduced sleep quantity and quality after night-time matches
Juliff, Halson & Peiffer, 2015	To identify sleep complaints of athletes prior to competitions and determine whether complaints were confined to competition periods	Team and individual sports	Elite	Cross-sectional study/questionnaire	Short-term	64.0% of athletes reported worse sleep on at least one occasion in the nights prior to an important competition
McEwan, Davy & Christie, 2020	To investigate the athletes' sleep behaviours during home and away competition.	Cricket	Elite	Longitudinal field-based investiga-tion/questionnaire	Short-term	Sleep disruptions were observed particularly after periods of travel and match play
Murdaugh et al., 2018	To determine the relation between sleep quantity and sleep disturbances on symptoms and neurocognitive ability during the acute phase (<7d) and after sports-related concussion	(Not stated)	(Not stated)	Prospective inception cohort study/the Immediate Post-Concussive Assessment and Cognitive Testing (ImPACT) neurocognitive and symptom inventory	Long-term	Low sleep quantity and sleep disturbances following concussion history
Shearer et al., 2015	To examine pre- and post-match sleep patterns in elite rugby players	Rugby	Elite	Not stated/wrist activity monitors (Actiwatch®)	Short-term	Decrease in post-match sleep that could effect in impaired recovery
Stevens et al., 2018	To determine the effects of long-haul northeast travel for competition on sleep	Triathletes	Trained	Prospective cohort study/sleep diaries and wrist activity monitors	Short-term	Decrease in sleep duration on the over-night flight and decreased on the night prior to competition

- travel (jetlag, sleeping on the bus, staying away from home) [16—20],
- night performance [21—24],
- prior, during and post competition (nervousness and anxiety pre-competition, and outcomes of the contest) [17,18,25—28];

- long-term effects of sleep:
  - history of concussion [29—31].

4. Discussion

This study aimed to identify themes in peer reviewed studies that can give an insight into possibly causes of sleep deprivation in competitive athletes. 16 studies were identified in the scoping review and split into two main categories, short- and long-term causes. The short-term causes were aligned to 3 sub-themes: (1) travel, (2) night performance, (3) prior to, during and following a competition. A single theme of concussion was noted in the long-term category. This scoping review, in contrast to other reviews, focused on possible causes of sleep disturbances, rather than an investigation of sleep deprivation outcomes. The aim was to gives coaches, athletes and practitioners an insight to causality and this can be used to devise a coping mechanism.

4.1. Short-term causes of sleep deprivation

4.1.1. Travel

From the 16 studies in this scoping review 5 studies found that long-haul travel, sleeping on the bus or in unfamiliar environment have an impact on sleep and self-reported fatigue. Sleep loss was associated with reduced alertness, slowed reaction time and in particular showed adversely effects on cognitive ability [18,20]. The negative impact on sleep remained for up to 5 days, and subjective jet lag symptoms continued for up to 13 days.

A separate study in this sub-category conducted by Stevens et al. [19] looked at endurance athletes and found 25% of participants reported upper respiratory discomfort after a long-haul flight. The participants noted the symptoms persisted between 1 and 5 days after arrival (including race day). Despite the increase in self-reported fatigue in athletes, Stevens et al. [19] stated no changes in sleep quality across the study and an increase in sleep duration (1.15; $\pm$0.92 h). In contrast Biggins et al. [16] identified a significant decrease in the sleep quality ($P < 0.001$) and sleep hygiene of elite male and female soccer players after a long-haul flight.

The finding of this scoping review ascertained that the negative impact of traveling to competition was not confined to long-haul flights, but various types of travel. A study that investigated the impact of short-haul travel on sleep found significant reduction in sleep quantity (sleep duration 321.6 $\pm$ 34 min) ($P = 0.005$) when players were required to sleep on the bus compared to sleeping at home [20].

Finally, two studies showed that travelling to away games resulted in significant lower post-travel sleep onset latency ($P = 0.01$) and moderately delayed sleep onset times ($P = 0.12$) believed by authors to be caused by difficulties in falling asleep in an unfamiliar environment due to travelling away from home [17,18].

4.1.2. Night performance

The second theme identified in this category was the impact of late-night performance on athletes' sleep and recovery. Reduced sleep quantity and quality was caused by a later bedtime and linked to increase heart rate during sleep, heightened feeling of pain and nervousness following a night match or training. Four studies [21—24] identified in this scoping review analysed the effect of night matches (NM) and night training (NT) on sleep patterns. The studies compared sleep patterns to either a training day (TD), days matches (DM) or rest days (RD). All studies showed at least one significant change in sleep quality or quantity as a result of a night performance. The majority of the studies showed a moderate to significant reduction in total sleep duration. Two of the studies found significant changes in sleep patterns after NM compared to DM ($P < 0.001$) [22,24]. Similar results were noted by Fullagar et al. [24], were sleep restfulness was significantly higher following NM than both TD ($P < 0.001$) and DM ($P = 0.007$) with a greater sleep onset latency ($P = 0.03$). However, a study on female soccer players showed no differences in sleep efficiency after NM compared to TD and RD ($P > 0.05$) [23].

A relationship to sleep disruption was not confined to competition, training time and workload also had an effect on sleep patterns and physical state. For example, significant changes in the whole-night mean nocturnal heart rate and core body temperature ($P < 0.01$) were observed after night-time high-intensity, intermittent training compared to resting conditions [23]. Costa et al. [23] found that night training significantly affected total sleep time ($P = 0.005$) and sleep onset time ($P = 0.001$). Small effects ($P > 0.05$) on sleep latency, time in bed and wake up time were also reported. Additionally, Aloulou et al. [21] reported an increase in light sleep and decreased in REM sleep ($P < 0.05$) in endurance athletes after light-night training.

4.1.3. Prior to, during and post competition

The final theme ascertained in this category was changes in normal sleep patterns during a competition period. Seven out of 16 studies in this scoping review investigated sleep patterns during what was termed a competition period [28]. This was a period several days before the competition up to several days following the event. Studies assessing sleep quality pre-competition showed interrupted sleep patterns, particularly prior to important competitions [16,27]. Biggins et al. [16] analysed 20 elite female athletes prior to an international soccer tournament and reported significant lower sleep duration ($P = 0.028$), shorter time in bed ($P = 0.006$), and decreased sleep quality ($P < 0.001$) when compared to males. Juliff, Halson and Peiffer [27], looked at sleep disturbances in the Australian Olympic team prior to competition. The most reported issue was an inability to fall asleep (82.1%) due to nervousness/thoughts about the competition. The study also looked at the variation between team and individual sports. Individual athletes reported a lower level of sleep disturbances compared to team sport athletes ($P = 0.005$). A greater percentage of team sports athletes (59.1%) reported a lack of coping strategies to prevent sleep disruptions prior to competition compared to individual athletes ($P = 0.002$). Only one study [18] reported no change in pre-competition sleep patterns which involving cricket

players. McEwan, Davy and Christie [18], noted that players developed effective strategies during the competitive season to cope with pre-competitions nerves [18].

A number of studies also looked at the quality and quantity of sleep in athletes post competition. Driller and Cupples [26] identified a significant reduction in total sleep time and lower sleep efficiency (68%, $P < 0.05$) on the night of a competition compared to the night before or after the competition. Driller and Cupples [26] also reported that players spent significantly less time in bed ($P < 0.0001$), gained less total sleep ($P < 0.0001$) and went to bed later ($P < 0.0001$) post-match compared to pre-match. Athletes reported lower subjective sleep quality ($P = 0.0002$) and obtained lower morning freshness scores ($P < 0.0001$) [18].

The outcome of a competition also had an impact on an athletes sleep patterns as noted by both Chennaoui et al. [25] and Fox et al. [17]. Both studies analysed sleep patterns the evening of competition and reported sleep irregularities depending on the outcomes of the competition. Chennaoui et al. [25] and Fox et al. [17] noted a higher quantity of sleep in the loosing group ($P < 0.005$) compared to the winning group. The loosing group had later sleep onset ($P = 0.18$) however the winning demonstrated higher sleep fragmentation (p= 0.17) after the match compared to those who lost. Additionally, unbalanced games resulted in later sleep onset in all athletes ($P < 0.05$) [17].

4.1.4. Long-term causes of sleep deprivation

In addition to the short-term effect on sleep deprivation this scoping review identified one theme that had long term effect on sleep deprivation. Blake et al. [29], Bliznak et al. [30] and Murdaugh et al. [31] noted that concussion had a long term impact on athletes sleep patterns. All three studies investigated the impact of sport-related concussions on sleep disturbances. The results showed that a history of concussion significantly increased the risk of serious sleep disorders, chronic fatigue, and lower quality of life [29,30]. Concussion was associated with difficulty falling asleep, restlessness, lower sleep duration, and difficulty staying asleep. The findings are consistent with studies by Mathias and Alvaro [32] and Bryan [33], which showed a significantly increased risk of sleep disturbances (50%) and insomnia following the incidence of concussion. In a study investigating sleep quantity and sleep disturbances during recovery from sports-related concussion, insufficient sleep, particularly in young athletes impacted migraine, and cognitive and neuropsychological symptoms [31]. Understanding and managing post-concussion sleep problems is critical as lack of sleep enlarges post-concussion symptoms such as chronic pain, vestibular dysfunction and vestibular dysfunction [34].

5. Conclusion

It is evident from the studies in this review that sleep deprivation has an impact on performance and competition. Despite this affirmation there has only been individual studies that have looked at the cause of sleep deprivation in competitive athletes. It is hoped that the current contribution of this scoping review will begin to broaden the knowledge and causation of sleep deprivation in competitive athletes. The current review is not a definitive summary of causes, but a starting point to inform coaches, practitioners, and future research.

6. Practical application

The findings of the scoping review suggest there are opportunities for coaches and practitioners to implements interventions that would reduce the effect of sleep deprivation on athletes prior and post competition. Coaches and practitioners should consider the timing of travel and allow for a climatization period prior to competition, this may have a positive impact on an athletes sleep patterns. While devising a psychological intervention strategy for athletes to cope with pre-competitions nerves may aid with sleep patterns and have a positive effect on performance.

During times of heavy training load coaches may wish to consider prescribing training earlier in the day and avoid late night training session as this will help with sleep and aid recovery.

Disclosure of interest

The authors declare that they have no competing interest.

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