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REVIEW

How to Enhance Sleep for Athletes? A Narrative Review of Sleep Hygiene and Sleep Extension Practices

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Abstract

Purpose of Review Sleep is becoming widely accepted as a crucial for athletes, with potential impacts on both performance and recovery, yet despite this, sleep amongst athletes is commonly suboptimal. This review aims firstly to summarise underlying reasons why athletes commonly present with poor sleep with a view to informing subsequent interventions, and secondly, to summarise sleep hygiene and sleep extension practices to potentially offset this, with consideration for the content and delivery approach of such interventions.

Recent Findings Approaches to sleep hygiene education should be individualised where possible, with a view towards a collaborate process involving both athlete and coach. Contemporary methods of sleep hygiene education, such as media messaging, may warrant further investigation within an athletic cohort.

Summary Education on sleep hygiene factors may be a beneficial intervention if athletes are presenting with sub-optimal sleep according to normative values. Both sleep hygiene and sleep extension have been shown to be successful strategies in improving both sleep factors and athlete performance, yet further longitudinal studies are needed in this remit to determine optimal methods of maintaining such improvements.

Keywords Sleep hygiene · Sleep extension · Recovery · Athletes · Sport

Introduction

Success in sport is underpinned by optimal preparation and recovery [1], with sleep being highlighted as the single most important recovery strategy available to an athlete [2]. Short sleep has been shown to negatively affect sports specific skills, coordination, mood, rating of perceived exertion and injury risk [3–5]; therefore, optimising sleep for athletes is of paramount importance for both sports performance and athlete wellbeing. Yet despite the consideration that sleep should be considered as foundational for athlete recovery [6], sleep is still an area where many athletes are operating sub-optimally [7, 8]. A fundamental difference between other popular recovery strategies (i.e., ice baths, compression garments) and sleep, is that sleep initiation does not depend solely on the willingness of the athlete or instruction of the coach [9], but rather, can be limited by current physiological state. Therefore, consideration around sleep optimisation for athletes' is a growing area of interest within sport [5].

Many aspects of performance have been demonstrated to be affected by sleep, including speed, sport-specific skills and jump performance [10–12]. Furthermore, multiple psychological parameters are affected by short sleep, with low mood, greater rating of perceived exertion (RPE), and decreased alertness [13–15] evident after short sleep; all of which may negatively affect physical performance. Physiologically, sleep deprivation induces increased levels of pro-inflammatory markers [16], whilst changes are also evident at a metabolic level, namely increasing concentrations of certain neuromodulators, such as adenosine, which generally inhibits neural activity via the stimulation of A_{2A} receptors to express sleep promoting neurons [16]. Indeed, the subsequent response of increasing sleep pressure and

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tiredness may be one underpinning mechanism behind the observed modulation of physical performance in response to sleep adjustment. From the viewpoint of overall athlete wellbeing, the importance of sleep for emotional regulation and maintaining overall mental health in athletes, as well as reducing potential illness and injury risk has been highlighted [5].

Despite clear evidence presenting the importance of sleep within athletic cohorts, sleep continues to be problematic for many athletes, and many athletes operate with sub-optimal sleep daily. In a review of 12 studies of Olympic athletes ($n = 596$), mean sleep duration across pooled data was 6 h 10 min [17]. In collegiate athletes, a population where sleep problems are commonly reported due to training and lifestyle factors, the average sleep duration was 7 h 4 min [18]; the same study went on to report that athletes needed an average sleep duration of 7 h 58 min to maintain physical and mental health-related quality of life, as analysed by receiver operating characteristics curve analysis [18]. The question of how much sleep athletes need is an important one; a survey of 175 elite athletes ($n = 30$ women, $n = 145$ men) found only 3% of athletes stated they regularly obtain enough sleep to satisfy their self-perceived needs; there was an average sleep deficit (self-assessed sleep needs minus objective sleep measure) of ~60 minutes [19]. The authors concluded athletes need 8.3 h of sleep per night to report satisfaction with their sleep, however the consideration of individual variation within this suggestion is likely to be warranted.

The measuring and monitoring of sleep duration within athletic cohorts is commonly self-reported as part of daily wellness check ins [20], or via actigraph devices. Whilst self-reported measures have previously been suggested to be informative for other recovery parameters, significant differences have been evidenced between self-reported and actigraph-reported sleep durations in female athletes [21, 22]. Gooderick et al. [22] directly compared self-reported and actigraph reported sleep durations of female athletes. The authors reported limits of agreement which spanned ~ 2 h, with a mean bias of 32 min, thus suggesting self-reported sleep durations to be a questionable approach to monitoring sleep duration in this cohort. Previously, actigraph-reported sleep durations have been validated against polysomnography, with the two methods showing good agreement for the measurement of sleep duration [23, 24]. Therefore, where possible within situational constraints, it is advised that practitioners take objective measures of sleep durations in order to inform any sleep interventions.

Practitioners have a growing range of methodologies at their disposal to support athletes sleep, and the number of studies investigating sleep and athletic performance has grown exponentially over recent years [25]. Interventions targeting sleep improvements range from mindfulness [26], thermoregulatory adjustments [27] or cryotherapy [28]. The use of sleep extension protocols, either with our without sleep hygiene education, are two methods commonly employed within athletic settings. Sleep hygiene can be defined as the promotion of habits that facilitate sleep, and avoidance of behaviours that inhibit sleep [29], whereas sleep extension interventions are more commonly administered via simple instructions of bed timings and targeted sleep durations. Understanding the potential impact of different sleep interventions to improve sleep is of value to coaches and practitioners aiming to address sub-optimal sleep amongst athletes, from a perspective of enhancing physical performance, overall health and athlete wellbeing. The aim of this narrative review was to summarise existing literature firstly highlighting specific considerations which may be contributory for poor sleep in athletes, and secondly, review sleep hygiene and sleep extension protocols to optimise athletes' nocturnal sleep, with the purpose of providing clarity to practitioners on optimal approaches in the remit of sleep management.

Athlete-specific Risk Factors for Poor Sleep

Athletes face a unique set of lifestyle stressors which may negatively contribute to sleep issues and the prevalence of poor sleep habits amongst athletes has been reported to be high [4]. Whilst sleep disruption may not always be of multiple hours on a daily basis, it can certainly be observed that many athletes are habitually below suggested optimal markers for many components of sleep [4, 19], including sleep duration [30], sleep quality [31], and sleep latency [32]. Competing demands between optimal recovery, training schedules and match timings, chronic sleep disturbances, in addition to restricted sleep opportunities, may be contributing to increased daytime fatigue and performance deficits [33].

Factors which may affect athletes' sleep include muscle soreness, injury, circadian disruption (jetlag), competition arousal or psychological stress [4]. This combination of lifestyle factors and stressors is commonly characterised by habitually short sleep durations [19], self-reported dissatisfaction with sleep [34], increased sleep latency [35] and high incidences of daytime fatigue [36]. Specific to the considerations of soreness and injury, pain has been reported as being a factor which may affect sleep [37], with nocturnal pain associated with poor sleep quality [38]. Increases of pro-inflammatory cytokines following physical exertion may affect both sleep regulation and sleep architecture [39]; pro-inflammatory cytokines may mediate the output of certain neurotransmitters, such as serotonin [40]. Furthermore,

one direct influence on sleep is the regulation of body temperature for sleep initiation. Previous studies have compared sleep indices of Olympic athletes to non-athletes and reported shorter sleep duration and worse sleep quality for athletes compared with age and sex-matched controls [30]. Evidence indicates clinical sleep problems may be common amongst elite athletes, with a systematic review demonstrating a high prevalence of insomnia symptoms within this cohort [33]. On a practical level, this should direct practitioners towards sleep monitoring at regular intervals, to determine the level of intervention necessary on an individual basis.

Psychological stress, particularly during pre-competition periods, has also been highlighted as a key cause of sleep disruption for athletes [4]. There is a significant body of research demonstrating excessive stress and anxiety to negatively affect sleep [41]. The role of competition stress must be considered when reviewing athletes' sleep [42], with sleep issues having been reported as being magnified post-competition [43]. In a survey of 283 elite athletes, 64% indicated they had worse sleep than normal pre-competition [1]. Furthermore, the most reported issues impacting sleep factors within that cohort were those of increased latency (82.1%), underpinned by "thoughts about the competition" (83.5%), and nervousness (43.8%). Given the regularity of competition many athletes face, proactively addressing this via psychological considerations within sleep hygiene interventions, with a view to potential mitigation of these factors appears prudent, particularly in many sports such as football, where weekly competition is common throughout the season. This may suggest team sports athletes to be of greater need for sleep hygiene interventions, although further research is needed to investigate this hypothesis. The need to appreciate other areas of potential stress for athletes, external to sporting considerations, has also been noted [42]. When compiling sleep hygiene interventions, practitioners should consider a holistic approach to sleep management, with consideration for lifestyle, including stressors, and routine preference.

Many athletes routinely tolerate training and competition schedules which are not conducive to supporting healthy sleep habits, whilst amongst elite athletes, the addition of travel requirements can often provide an additional stressor [42]. The timing of training and competitions are often factors which are not within direct control yet can significantly negatively affect overall sleep. Late night games in team sports have previously evidenced shorter sleep durations and later sleep onset following the match [43]. A similar disruptive effect is observed when training sessions are placed in the early morning and enforce an earlier wake time than preferred, shortening sleep duration the prior night [44]. The combination of early training and late competitions can result in substantial changes in irregular sleep timing and duration across the week [45, 46]. The use of caffeine both pre- and within matches and competitions are widely reported within elite athlete cohorts [47], thus education around the potential negative effects of this strategy, the dosage and implementation of down-regulation strategies post-match must be considered. Furthermore, it has been highlighted that light exposure from evening training or competing could be enough to stimulate wakefulness [48], which when considered in combination with potential evening screen use, may cause significantly disruption to athletes' sleep [5]. Whilst controlling for all contributory factors for poor sleep may be unrealistic, adjustment to specific situational constraints may be achievable via assessment on an individual basis.

Sleep Hygiene Education

Sleep hygiene education is a simple, non-invasive, low-cost strategy which can be used to enhance both sleep quality and quantity of athletes. Sleep hygiene has been cited as an integral factor in the promotion of healthy sleep habits [29] and improving the sleep hygiene of athletes can also result in increased sleep duration, efficiency, and latency [35, 43]. Therefore, the use of such interventions within an athlete population is becoming recognised as an important part of an overall training programme, with the aim of reducing sleep deficit and preventing chronic sleep deprivation; therefore, the implementation of regular sleep education to all athletes has been recommended to optimise and manage sleep [5]. Furthermore, this approach has the added benefit of providing education to the athlete, with evidence suggesting behavioural change is more likely to occur if education is provided alongside the suggested change, rather than a dictatorial approach of eliciting behaviour change [49]. With consideration to a holistic athlete development, sleep hygiene education may be a valuable tool in supporting sleep requirements of athletes throughout their career.

Key aspects of sleep hygiene education include but are not limited to, education around the impact of evening light exposure [50], maintaining regular sleep timings [51], reducing technology use in the evening from the perspective of both light reduction and psychological stimulation [52, 53], reducing caffeine consumption [54], and maintaining a cool, dark and quiet bedroom environment [55]. Delivery of such educational components around sleep habits must be done with appreciation for the individual athlete, and interventions should be individualised where possible [12]; this holistic approach, gives appreciation for individual athlete circumstances and preference.

A survey of 86 Australian sport coaches and sports science staff, all of whom worked in a high-performance

environment, and found only 43% had promoted sleep hygiene to their athletes [56]. The 57% of coaches who had never used sleep hygiene education with their athletes stated this was due to lack of knowledge and a lack of resources. This serves to highlight the potential gap in the working practices of sport coaches and the need for educational resources around sleep hygiene to be easily available to coaches. Therefore, it was stated identifying and addressing poor sleep amongst athletes is a key clinical and research concern, with potential impacts on athlete performance, recovery, and long-term wellbeing [57, 58]. A summary of sleep hygiene studies aiming to affect sleep parameters for athletes is detailed in Table 1 below. The available literature presents range of methodological approaches to enhancing sleep hygiene, such as education leaflets, group presentations, individual discussions and visual media messaging, therefore, the selection of an optimal approach may be challenging for practitioners.

In the selection of a sleep hygiene approach for an athlete cohort, practitioners should be encouraged to consider their own situational constraints which will likely direct selection, and use baseline monitoring to review the efficacy of the strategy. To the authors knowledge, only three studies have suggested sleep hygiene interventions to have no impact on sleep indices. Dunican et al. [66] implemented both group sleep hygiene education sessions and individual sleep hygiene education to female basketballers which has no significant effect on sleep parameters (Table 1). The authors noted that players reported a mean sleep duration of 8 h 10 min prior to intervention, thus suggested a ceiling effect for improvement given sleep durations were already in a healthy state. It was also noted the training schedule at the time of the study was highly conducive to supporting sleep and recovery, with no morning training scheduled and no additional activities (e.g., media promotions) scheduled before 9.00am. These two considerations may account for the non-significant results observed.

Jenkins et al. [65] implemented a 30-min SH presentation to elite male rugby players mid-season which failed to improve sleep indices (Table 1) The authors attributed their non-significant findings to the fact that the competitive season has potentially greater stress and distraction than pre-season, and subsequently suggested that sleep hygiene education should be carried out in off-season or pre-season, to maximise the potential for changing sleep behaviours. Dunican et al. [68] implemented a 2-hour sleep education session with 30 min questions and found this to be insufficient to create significant changes to sleep indices (Table 1). Similar to Dunican et al. [66], the authors attributed this to the fact that the mean sleep duration of participants pre-intervention was already close to optimal recommendations, supporting earlier suggestions of a ceiling effect for sleep improvements. With this consideration, if baseline monitoring shows athletes' sleep durations are above aforementioned recommendations, the implementation of sleep hygiene strategies may not be warranted.

Additionally, it is interesting to note the latter two studies presenting unsuccessful sleep hygiene interventions, delivered the intervention in a group-based presentation, which may infer this may not be the optimal method of delivering this information, and neither study presented any consideration regarding the potential impact of individual delivering the education session. Dunican et al. [68] stated "The sleep education session was provided by an expert (PhD) qualified in sleep and performance in athletes", whilst Jenkins et al. [65] stated "The sleep hygiene intervention was delivered by the lead researcher". Both descriptions failed to detail the level of familiarity of the educator to the participant group, or additional compounding factors such as cultural literacy, professional identity, or the proximity to either insider or outsider research spectrum [70, 71], key considerations why may also have contributed to the lack of success of the intervention. Table 1 presented studies demonstrating both successful and unsuccessful sleep hygiene interventions with male and female participants (Table 1), it would seem there are no obvious gender differences in the efficacy of sleep hygiene strategies, however further research is needed to enable direct comparison and quantification of this observational assessment. Rather, it would seem unsuccessful sleep hygiene interventions are more likely to be due to pre-intervention sleep habits (ceiling effect), intervention timing (in-season), or due to the methodology of the approach (group delivery, and the individual delivering the information).

The effects of sleep hygiene education have sometimes been described as transient, with sleep improvements seemingly dissipating post-intervention. Indeed, previous work has demonstrated sleep improvements were not maintained one month post intervention [35]. Short term improvements were also found by Vitale et al. [64], who found sleep hygiene education to be useful to reduce sleep onset latency and increase sleep duration following a late-night football match, but these sleep improvements were not maintained two nights following the education. It has previously been stated that an understanding of the athletes' environment, economic circumstances and culture may help to support changes in sleep habits [42]. This is suggestive of the need to take a holistic approach, with appreciation towards an individualised perspective, encompassing discussion around underpinning reasons behind current habits and potential barriers to initiating change. In a study comparing the efficacy of both group-based sleep hygiene education and individualised sleep hygiene education, the addition of individualised SH education resulted in significant improvements across a greater number of sleep factors

Table 1 A summary of sleep hygiene studies demonstrating the experimental design, protocol and results of the intervention (SH– sleep hygiene, SD– standard deviation, ESS– Epsworth sleepiness scale, MAF– Multidimensional assessment of fatigue, PSQI– Pittsburgh sleep quality index, ASBQ– Athlete sleep behaviour Questionnaire)

Study	Participants	Experimental Design	Protocol	Main findings
Fullagar et al. [53]	20 male semi-professional footballers. Mean age 25.9 ± 7.5 years.	Crossover study	3-day baseline sleep measurements. Group SH delivery post-match or normal post-match routine. One week washout between conditions. Sleep monitoring for two nights post-match.	Significant increase in sleep duration for SH intervention post-match. No difference in sleep quality
Harada et al. [59]	84 male footballers. Age 18–22 years (mean ± SD not provided)	Single group pre-post design	SH leaflet of 8 recommendations, with one month of suggested intervention. Baseline questionnaires were completed, and repeated 3 months post intervention.	Sleep quality significantly increased, and irritation decreased post intervention. Football performance showed initial improvement post intervention.
Kaier et al. [60]	104 student athletes (n = 97 female). Mean age 20.0 ± 1.4 years.	Single group pre-post design	Group SH workshop intervention. Questionnaires complete at baselines, post workshop and 3–4 months follow up.	Significant improvement in daytime sleepiness, and daytime fatigue, reported by ESS MAF.
O'Donnell and Driller [61]	26 elite female netballers. Mean age 23.0 ± 6.0 years.	Single group pre-post design	One week baseline sleep monitoring. 1 h SH presentation to all. One week post intervention sleep monitoring	Significant increase in sleep duration and wake variance.
Van Ryswyk et al. [62]	25 male Australian rules football. Mean age 23.7 ± 2.0 years.	Single group pre-post design	2 × 1 h SH group sessions and individual progress updates	Significantly improved sleep efficiency. Mood improvements observed for fatigue and vigour.
Caia et al. [35]	24 male rugby league players. Mean age 25.4 ± 3.3 years.	Median split	2-week baseline sleep monitoring. 2 × 30 min SH sessions. 2 weeks post intervention sleep monitoring. 1 month follow up.	Significant increase in sleep duration and earlier bedtime. All sleep variables comparable to baselines in 1 month follow up.
Driller et al. [63]	9 elite male cricketers. Mean age 23.0 ± 4.0 years.	Single group pre-post design	3-week baseline sleep monitoring. 50 min group SH session and 30 min individual session. 3-week sleep monitoring post intervention	Sleep quality, sleep latency and sleep efficiency all significantly improved post SH education.
Vitale et al. [64]	29 recreational male footballers. Mean age 25.5 ± 6.5 years.	Randomised controlled trial. Control group and experimental group receiving SH education.	One night sleep baseline. Experimental group– 45 min group SH session post-match. 2 nights follow up post intervention.	Sleep latency and sleep quality post-match significantly increased when receiving acute SH intervention.
Jenkins et al. [65]	14 male rugby union players. Mean age 24.0 ± 4.3 years.	Single group pre-post design	3-week baseline. 30 min SH education presentation to all. Sleep monitoring for 3 weeks post, plus final follow up 2 weeks later.	No significant changes in any sleep variables throughout 8 weeks.
Dunican et al. [66]	12 female professional basketball players. Mean age 25.0 ± 2.0 years.	Single group pre-post design	1-month baselines. Group SH education (~2 h) and 1:1 consultation (~20 min). 1 month monitoring post intervention	No significant improvements to any sleep parameters post intervention.
Edinborough et al. [67]	1 Professional male footballer. Age 17.6 years.	Case study	7 days baseline. Individualised SH provided based on baseline data. 8 days post-intervention monitoring.	Number of wakings per night improved post SH intervention. Improved subjective scores on PSQI and ESS.
Dunican et al. [68]	24 masters swimming athletes (n = 13 female). Mean age 39.0 ± 11.0 years.	Prospective pre-post design	42 days baselines. 2-hour SH group presentation, with 30 min questions in group setting. 42 days monitoring post-intervention	No significant improvements in any measures of sleep post- intervention.
Gooderick et al. [12]	34 female footballers. Mean age 20.3 ± 1.4 years.	Randomised, controlled trial with repeated measures. Three groups– control, one receiving only group SH education, one receiving both group and individual SH education	1 week baselines. One group SH education session (40 min) for both intervention groups. One group received additional individualised SH education following that (1 × 30 min, 1 × 20 min).	Participants receiving individualised SH education significantly improved sleep quality compared to those solely receiving group SH education. Individual SH group significantly improved all sleep indices compared to control group.

Table 1 (continued)

Study	Participants	Experimental Design	Protocol	Main findings
Gooderick et al. [69]	16 professional female footballers, mean age 24.4 ± 2.6 years	Self-controlled case series design	One week baselines. 10 min individual discussions with participants reviewing baseline data. Individualised SH education delivered over 2 weeks via media messaging	Significant improvements observed post intervention for sleep efficiency, sleep latency and ASBQ score.

than group education alone, leading the authors to conclude the importance of some level of individualisation within sleep hygiene education [12]. Further longitudinal studies are needed in this remit, investigating the potential for educational "top ups" to maintain initial benefits.

Recent studies have presented alternative methods of sleep hygiene education, across a range of different populations. Hassanin et al. [72] used sleep hygiene videos (2.44–3.27 min long) with fifth and sixth grade children ($n = 49$) with the cartoon videos designed to educate on the importance of sleep and practical tips. The authors observed a positive change in the Pittsburgh sleep quality index score, 13.6% improvement in SD, 10.9% improvement in sleep disturbance and 22% improvement in sleep latency. Similarly, in a preintervention study, Putri [73] described the initial trials of sleep hygiene videos (3–6 min long) for the elderly, with all videos delivered via WhatsApp for the reasons of cost and time efficiency. Media based methods of sleep hygiene education have also been demonstrated within an athlete population, implementing sleep hygiene education delivered via media messaging for professional female footballers [69]. The messages, delivered at a standardised time of 8pm, were successful in improving sleep latency, efficiency and ASBQ scores for professional footballers mid-season. This novel approach has the potential to be individualised and may be beneficial from a point of resource efficiency in some professional sport settings. Further research into the longevity of this strategy is needed throughout a season.

While diverse approaches have been taken to sleep hygiene education in athletes, it is important for future research to evaluate which intervention components used elicit the most beneficial behavioural changes to improve sleep outcomes, and to build upon these. Research has attempted to summarise previous educational interventions in athletes using the Behaviour Change Technique Taxonomy [74] to break down the intervention content into the components that drive sleep behaviour change [75]. It was found that these interventions tend to employ similar components such as shaping knowledge through instruction (e.g., providing information on sleep regulation) and being delivered by a credible source (e.g., sleep researchers). However, there were various groupings of behaviour change techniques that had only been employed by either a single study or no studies. Sleep hygiene education arguably offers the perfect platform to integrate different behavioural approaches into the delivery, and having studies clearly specify which components within their intervention are attempting to drive sleep-related behaviour change will enable meaningful comparisons to be drawn between studies in the future. Furthermore, studies detailed in Table 1 presents participants from an age range of 17–39 years, suggesting a lack of research investigating sleep hygiene education for youth athletes; yet, given the potential for using such strategies as a foundation for the long-term formation of healthy sleep behaviours, further research is indicated in this remit.

Sleep Extension Without Sleep Hygiene Education

Nocturnal sleep extension can be described as an increase in habitual total sleep time (76In the absence of an education-based approach, sleep extension studies commonly achieve the goal of extending an athletes' sleep by setting rigid bed times, and wake times, with time spent in bed dictated objectively. Mah et al. [10] implemented a sleep extension intervention, by setting collegiate basketball players a target of 10 h in bed per night. They found that increasing sleep durations resulted in significantly improved sprint times (16.2 ± 0.61 s at baseline vs. 15.5 ± 0.54 s at end of sleep extension), shooting accuracy (free throw percentage increasing by 9%), reaction time (decreased psychomotor vigilance task scores) and enhanced self-perceived mental wellbeing. Supporting this finding, increasing nightly sleep durations of collegiate tennis players improved serving accuracy by 17% [11]. This suggests optimising sleep can help to improve objective markers of sports performance, and thus education around methods of optimising sleep could be of value. With a lack of habitual change likely to have occurred in response to simple instructions over dictated sleep timings, further longitudinal studies are needed in this remit to determine whether dictated sleep extension can be maintained over the course of a season.

Roberts et al. [76] used a counterbalanced crossover design, over 7 days of data collection, to assess differences in endurance performance between three groups: one group who maintained their normal sleep patterns throughout, one group who reduced their sleep by 30% from baseline

values, one group who aimed to extend their sleep by 30% from baseline values. Compared to the normal sleep group, endurance time trials on all testing days were slower in the sleep reduction group. Sleep extension for 3 nights led to better maintenance of endurance performance compared to normal and restricted sleep groups, leading to the conclusions that cumulative sleep time affects performance at a given exercise intensity. In the absence of testing for physiological markers of fatigue, it was hypothesised this performance reduction was due to the alteration of RPE. Although there is a lack of substantial evidence to support these conclusions, this study is of value in providing recommendations for the use of sleep extension to improve performance, demonstrating a 3-day adjustment was necessary to produce a short-term improvement in performance. This is worthy of consideration in the preparation for performance peaks for key sporting events. In a study adopting a randomised, crossover design, Leduc et al. [77] asked participants to either sleep for 10 h post rugby training session (sleep extension) or attend an early morning recovery session (control). If participants were in the sleep extension group, they received verbal and written instructions on bed timings. Participants following sleep extension demonstrated increases in total sleep time compared to controls, whilst at 14 h post training, significant improvements were observed in cognitive functioning compared to the control group. However, at 36 h post training, no significant differences were observed between the groups, suggesting recovery strategies in themselves are indeed acute, and as such, strategies may be considered in the context of each situation.

Whilst the above studies demonstrate methods of sleep extension via the dictation of time in bed over a short-term period, the absence of longitudinal studies in this remit presents doubt over whether this technique could be maintained over the course of longer periods of time. One potential benefit of the use of sleep hygiene education compared to sleep extension delivered via set timings, is the distinction between self-determined and controlled motivations from a coaching perspective [78]. Self-determined motivations are to act with a sense of volition and choice, with behaviours endorsed by the individual [79]. This commonly results in more persistence and effort in continued engagement with the specific behaviours, whilst additionally increases in self-esteem are evident with this practice [78]. From a sleep hygiene perspective, this could be beneficial in longer maintenance of the strategy and the development of positive lifestyle habits. In contrast, controlled behaviours, such as giving rigid sleep timings to stick to, reflect a lack of personal endorsement or engagement in the process [79], and is suggestive of a more dictatorial approach, potential leading to disengagement following the cessation of the dictated behaviours.

Conclusions and Future Research Directions

Sleep is a key recovery strategy for athletes. Athletes face a unique set of lifestyle circumstances which are often counterproductive to optimising sleep factors, yet optimising sleep may be one way to gain both direct performance benefits, via the realisation of physical potential, and indirect performance benefits, via greater and more efficient recovery profiles. Many methods of sleep optimisation are available for coaches to consider. Sleep hygiene education provides a simple, low-cost approach to potential sleep enhancement for athletes, whereas sleep extension can be achieved via dictation of sleep timings. Delivery of sleep hygiene education should be considered to maximise effectiveness of the intervention, with consideration of many of the underpinning factors that affect athletes' sleep. Furthermore, consideration of the practitioner delivering the education, whether the education is delivered in a group or individualised format, and the medium of such educational delivery, whether this is in traditional modalities, or more contemporary methods such as media messaging, is likely to affect intervention success. Recent research presenting both the inter-individual variation of sleep habits and the success of individualised sleep interventions, should direct practitioners towards taking an individualised approach to sleep hygiene education where possible. Further research is needed to determine whether different approaches are warranted for athletes' from different sports (for example, endurance based vs. power based sports). Whilst sleep hygiene and sleep extension interventions have been shown to be effective in shorter term adjustments to athlete sleep habits, further research is directed towards the maintenance of such approaches, and future longitudinal studies are suggested in this remit. Commonalities across many studies present the concept of initial improvements with decay over time. As such, future research is directed towards the investigation of potential "top up" approaches, with an initial educational component delivered, followed by singular bouts of "top up" interventions over the course of a season. Given the supportive evidence for sleep hygiene education as a method of initiating positive behavioural change, future research should be directed towards this approach for improving sleep of youth athletes, and may be beneficial in the development of sustainable, healthy sleep habits.

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Declarations

Human and Animal Rights and Informed Consent All studies with human participants are published and followed ethical standards, detailed within individual publications.

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