Title: Sleep and recovery in team sport: current sleep related issues facing professional team-sport athletes

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ABSTRACT

Whilst the effects of sleep loss on performance have previously been reviewed, the effects of disturbed sleep on recovery following exercise are far less reported. Specifically, the interaction between sleep and physiological and psychological recovery in team-sport athletes is not well understood. Accordingly, the aim of the present review is to examine the current evidence of sleep and the potential role it may play in post-exercise recovery, with a tailored focus on professional team-sport athletes. Recent studies show that team-sport athletes are at high risk of poor sleep during and following competition. Although limited published data is available, these athletes also appear particularly susceptible to reductions in both sleep quality and duration following night competition and periods of heavy training. However, studies examining the relationship between sleep and recovery in such situations are lacking. Indeed, further observational sleep studies in team-sport athletes are required to confirm these concerns. Naps, sleep extension and sleep hygiene practices appear advantageous to performance; however, future proof of concept studies are now required to determine the efficacy of these interventions on the post-exercise recovery. Moreover, more research is required to understand how sleep interacts with numerous recovery responses within team-sport environments. This is pertinent given the regularity at which these teams encounter challenging scenarios during the course of a season. Taken collectively, this review will examine the factors that compromise sleep during a season and following competition, and discuss strategies which may help improve sleep in team-sport athletes.

KEYWORDS:

Regeneration, exercise, stress, soccer, circadian rhythms,

1. Introduction

High performance team-sport athletes endure numerous physiological, psychological and neuromuscular stressors during training and competition.[1] It is logical that these athletes balance these stressors with appropriate recovery to maximise performance and adaptation, whilst also minimising the injury risk.[2] A crucial part of this stress-recovery balance is the management of an athlete's sleep, especially during intense training and competition.[3] However, whilst the interest afforded to the relationship between sleep and athletic performance is well documented,[4] the evidence underpinning the role of sleep in recovery is less understood. This is surprising from both a scientific and applied perspective given athletes often rate sleep as their most important recovery strategy.[5]

There are three key factors which determine the recuperative outcome of sleep; the duration (total sleep time), quality and phase (circadian timing) of sleep.[6] A 'healthy' night of sleep has been suggested to be 7-9 h.[7] In addition to duration, sleep quality is also critical for optimal health and restorative functioning.[7] Although a clear definition is not readily available, sleep quality can best be outlined as the personal satisfaction of the sleep experience.[7] Further, the timing of sleep will also influence the effectiveness of the sleep bout. The timing of an individual's preferred bedtime in turn affects their circadian rhythms (i.e. body temperature, hormone regulation), which can impact both sleep duration and quality.[6] From an athletic perspective, disturbances to one or all of these collective aspects of sleep are suggested to affect the post-exercise recovery process.[6] For instance, it has been shown that a reduction in the quantity and quality of sleep hinders the capacity of rugby-league footballers to recover for the demands of ensuing training and competitive bouts.[8] Thus, it may be paramount for team-sport athletes to be aware of situations where disturbed sleep duration, quality or phase may affect ensuing recovery.

A reduction in sleep duration and/or quality in individual athletes prior to,[9-11] and during competition[12] has been recently documented. Whilst there is less information available on team-sport athletes, Lastella et al[13] reported a mean sleep duration of 7.0 h per night in 58 elite Australian team-sport athletes during a typical training phase, ~ one hour less than the recommended 8 h per night. Further to these findings, sleep disruption or deprivation can occur for team-sport athletes, particularly during short- or long-haul travel,[14-16] congested competition schedules,[1] and training or playing at night,[17] presenting the potential for compromised recovery.[3,8] Indeed, sleep loss in team-sport athletes is often affected by these situational factors,[18] with many professional teams currently facing the challenge of coping with these specific, but recurring stressors. For example, Major League baseballers play every two days combined with repeated travel across the United States, which provide conditions that are not conducive to optimal sleep.[19] Similarly, the majority of European soccer tournaments are commonly played at night, resulting in late night finishes and players subjectively reporting sleep loss.[20] These observations of altered sleep in team-sport athletes are also supported by objective evidence of post-competitive sleep disturbance in elite rugby union players[17] and professional Australian soccer players,[16] and a recent report that 52.3% of elite (individual and team sport) athletes experience sleep disturbances following late matches or training sessions.[18] Collectively, these data suggest that although ‘normal’ sleep patterns may be sufficient, under specific, recurring circumstances there are cases for reduced sleep durations and quality in team-sport athletes.

At present, the importance of sleep as a recovery method in team-sport athletes (i.e. return to baseline of psycho-physiological and performance parameters following exercise and disrupted sleep) is unclear. In particular, there is little analysis of the role sleep plays in the post-exercise recovery process during various situations where sleep is compromised. Whilst the literature examining the interaction between sleep and recovery in athletes is increasing (Figure 1), there have been no critical reviews of these factors in the context of training and competition demands of team-sport athletes. Accordingly, the aim of the current study was to examine the evidence of the potential role sleep may play in post-exercise recovery, with a specific focus on professional team-sport athletes. As such, an analysis of situations which may continually compromise sleep throughout a season and/or one-off post-competition sleep disturbance is provided. Strategies to alleviate such issues facing team-sport athletes are also addressed. For this review, it is important here to discern the difference between *recovery* and *performance*. From an athletic perspective, *performance* in absolute terms refers to the magnitude to which the athlete completes certain tasks within their sporting domain. These can include but are not limited to competition performance (e.g. goals scored by a footballer), predictors of performance (e.g. sprinting speed) and surrogate measures of performance (e.g. counter movement jump score). The effects of sleep loss on performance trials involve baseline performance measures followed by a sleep loss intervention/sleep control condition and then final performance measures the next morning/days. Comparatively, *recovery* refers to the *return* to baseline of performance parameters following a distinct exercise bout and disrupted sleep (e.g. return of creatine kinase to baseline values following a rugby match). Thus, the main discernible difference between performance and recovery is that recovery experiments follow a distinct time-course analysis from a prior stressor (i.e. match play). This makes making them suitable for the assessment of the health, wellbeing and readiness to perform of team-sport athletes.

INSERT FIGURE ONE

2. Sleep and recovery for team-sport athletes

A typical night of sleep is comprised of approximately 90-min cycles divided into periods of rapid-eye-movement (REM), and non-REM (NREM) sleep. Whilst REM sleep has a role in periodic brain activation, localized recuperative processes and emotional regulation, the role for NREM sleep is proposed to assist with energy conservation and nervous system recuperation.[21] Taken collectively, there is considerable evidence supporting the recuperative nature of sleep in restoring molecular homeostasis, cellular maintenance and synaptic plasticity.[6,21,22] From an athletic perspective, this implicates that disturbances to either the timing of sleep phases, or the quality and duration of sleep within these phases, can result in the hindrance of psychological and physical recovery following an exercise bout.[6] This would seem especially pertinent for field-based team sports that are typically exposed to prolonged bouts of intermittent-sprint activity during both high-intensity training and competition. Logically, exposure to such activity will increase the need for recovery and subsequently increase the overall requirement for sleep.[13]

From this perspective, it seems rational to first investigate the sleep-wake behaviour of team-sport athletes during and following training, and competition periods. Mah et al[23] reported mean average sleep durations of 6.7±1.0 h in collegiate basketballers during a competitive season. Similarly, Lastella et al[13] found a sample of 58 elite Australian team-sport athletes slept for a mean duration of 7.0±1.2 h during a regular training phase. With regard to sleep following competition, Eagles et al[17] found a significant reduction in sleep duration on game nights compared to non-game nights.[17] Juliff et al[18] reported that more than half of a sample of 283 elite individual and team-sport elite athletes (of which 210 were from team sports) endured sleep disturbances following a late training session or match.[18] In support of this, sleep duration and quality were significantly reduced on the night of away matches compared to the night prior in elite Australian soccer players.[16] Whilst caution needs to be taken in comparing these studies (i.e. due to differences in sleep-assessment methodologies), it seems reasonable to assume sleep in team-sport athletes is dependent on many factors. These could include the type of sport, training demands, age, time of season and team culture.[13] Taken collectively, high performance team-sport athletes are considered susceptible to sleep loss during training periods and following match play (especially at night). Whilst such insight is important, further descriptive research of sleep with high performance team-sport athletes is required to confirm this, most importantly for the nights following competition.

Recent studies have also shown that sleep restriction following team-sport competition affects the time course of recovery for both performance and psychophysiological measures. For instance, Skein and colleagues[8] investigated the effect of sleep deprivation (0 h sleep) compared with normal sleep (~8 h) on the physiological and perceptual recovery of eleven rugby-league footballers following competitive matches in a randomised cross-over design. Overall, sleep deprivation negatively affected recovery with significant impairments observed in mean and peak countermovement jump height and cognitive reaction time. Although sleep deprivation was excessive, this study highlights the increased physiological load during wakefulness following sleep loss in team sports, and in turn, suppression of cognitive function and lower body power. Similarly, Fowler et al[16] reported significant reductions in sleep duration and quality, along with an impaired stress-recovery balance, on the night of a match compared to the night prior for away matches. Whilst additional literature is lacking in team-sport athletes, there is further evidence of this relationship in individual athletes. For instance, significant reductions in sleep quantity and efficiency were associated with increased fatigue and impaired exercise capacity in a group of ten functionally-overreached elite synchronized swimmers.[24] Furthermore, McMurray and Brown[25] investigated the cardiovascular and metabolic responses of five participants during submaximal exercise following 24 h of sleep deprivation. They reported increased minute ventilation and oxygen uptake during the recovery period, suggesting negative effects of sleep loss on physiological recovery.[25] Nonetheless, the evidence as to how sleep interacts with multi-factorial recovery responses within high performance team-sport environments is currently lacking. In particular, there is little longitudinal objective sleep data available in the scientific literature. This is surprising given this would appear the first step in understanding the relationship between sleep and recovery.

Finally, since a variety of other recovery strategies are utilised in sport, some studies have also examined the interaction between sleep and these protocols. For instance, Robey et al[26] reported that cold water immersion post-training does not affect subsequent sleep duration, onset or efficiency. However, the mechanisms between the interaction of sleep and other recovery protocols are difficult to determine, due to an abundance of confounding factors (e.g. protocol type, timing, facilities). Further research and practical investigation within professional environments which address whether it is more advantageous to use a recovery protocol which enhances sleep and/or whether a combination of these protocols enhances the recovery process is warranted. This is especially pertinent given the wide prevalence of these methods in team sports.

3. Sleep-related issues facing team-sport athletes

As summarised in Figure 2, the following section outlines particular situations where sleep is at risk of compromise in team sport athletes. Whilst acknowledging the previous work done in this area but also recognising the absence of published data over prolonged periods, this gives particular relevance to situations during a season and/or one-off post-competition sleep disturbance.

INSERT FIGURE TWO

3.1Team-sport matches played at night

As often determined by television scheduling, numerous team-sports schedule the completion of matches at night. Indeed, the pure timing of matches (i.e. some matches in the Spanish La Liga commence at 22:00) will force players into later bedtimes.[27] Furthermore, since physical activity promotes arousal, it has long been assumed exercising during the evening hours produces a greater number of sleep disturbances than exercising during daylight.[28] Team-sport athletes also have extensive post-game commitments such as press conferences, recovery practises and social functions, which could lead to later bedtimes and disrupt sleep duration and quality.[1] As alluded to previously, Juliff et al[18] found 52.3% of a sample of 283 elite individual (n=73) and team-sport (n=210) athletes reported sleep disturbances following a night training session/match. Moreover, 59.1% of team-sport athletes reported that that did not use a strategy to overcome these sleep disturbances.[18] Furthermore, a recent review on regenerative interventions used in professional soccer explains that many medical doctors report players lose sleep following night matches, which include findings on elite Bundesliga soccer players subjectively reporting reduced sleep duration and quality.[20] Notwithstanding these findings, the anecdotal evidence of athletes reporting sleep disturbances following night competition outweighs that documented in the literature;

thus, further research in elite athletic populations is required to confirm this.

Recent data shows that performing maximal aerobic exercise in the evening results in elevated sleep onset latency, awakenings, and REM sleep latency - suggesting poorer overall sleep quality in judo competitors.[29] Whilst several physiological variables are elevated prior to sleep onset following late-night vigorous exercise (suggesting possible effects on cardiac autonomic control and metabolic function[30]), delayed sleep onset can also be caused by mental stimulation or cognitive fatigue.[22] Moreover, given pain is a significant predictor of a poor night's sleep,[31] it is likely prolonged late-night, high-intensity exercise (equivalent to match situations) will incur sleep disturbances throughout the night as a result of pain and soreness. This is of particular relevance for heavy contact sports such as American football, ice hockey, and rugby union. It should be noted that there is opposing evidence on the effect of competing at night on sleep. For instance, Roach et al[32] reported no effect of two night (19:00-21:00) matches on sleep in elite junior soccer players. Similarly, Robey et al[33] found no effect of early evening high-intensity training on the subsequent sleep quality or duration in elite youth soccer players. In light of this, it should be recognised that the mechanisms behind the effect of exercise (and timing) on sleep are complex due to the main confounding variable (amongst others) of the stress induced by the exercise itself. From an applied perspective, future research must first focus on providing objective evidence (e.g. acute and chronic measurements of actigraphy) on whether disturbances following match play at night occur. Researchers might also focus on the effects of disrupted sleep following match play in team-sport athletes and attempt to delineate the mechanisms responsible. At present, practitioners should also be aware of the intra-individual variability in sleep requirement and chronotype (those who arise early in the morning vs. those who prefer later bedtimes). Accommodating these differences within a team environment is difficult as it may require more individualised approaches. Indeed, this would be even more pertinent for team scheduling training the day after a game. For instance, it is common after a loss for coaches to train some of their athletes hard the day after match as 'punishment'. This may create recovery concerns given players will sleep differently after these night matches.

3.2 Sleep and travel fatigue

Cumulative sleep loss occurs as a consequence of travel during busy periods, which tends to lead to accumulative fatigue over a season.[34] Travel fatigue is dependent on the distance and frequency of travel, and the length of the season. It should be noted that travel-induced fatigue is separate to jet-lag fatigue, with the main difference being jet-lag comprises an effect of time-zone change.[34] The influences of jet-lag arising from long-haul international travel in elite athletes have been discussed previously[34,35] and thus will not be further addressed here. Sleep disturbances during or following travel can result in reductions in mood, acute fatigue and difficulty in initiating sleep at the arrival destination.[34] For team-sports, the method, mode, distance and timing of travel varies greatly and is largely dependent on scheduling, team budget and the coach's preference.[36] Many teams, particularly in America and Australia, endure one-way short haul domestic or international travel up to 6 h prior to or following competition.[19,37,38] In addition to sleep disturbances, travelling can result in detrimental health, impaired mood, dehydration and loss of motivation all of which can affect recovery.[34] Of further concern, it has been shown that baseball teams whose circadian rhythms are more synchronised to optimal performance times are more likely to be successful, indicating either a negative effect of travel and/or desynchronised body-clock functioning.[19] However, it should be noted that these data do not actually outline any physical or perceptual response to the travel, limiting its implication in athlete recovery.

Empirical data describing the effect of short-haul air travel on sleep, performance and the ensuing recovery in these situations is largely unknown. For instance, the sleep quantity and quality of players following away competition performance remains unclear, with short-haul air travel (1-3 h) affecting perceived sleep quality,[37] whereas some soccer players report earlier mean bed times after short-haul air travel (~5 h) and an away match.[16] Competition performance, along with reduced physical demands, appears to be greater at home compared to away (in American football[38], baseball[19], rugby league[14] and soccer[16]) suggesting either a negative effect of travel or a circadian advantage.[35] However, extrapolating these effects to determinations of match performance is difficult due to other external factors and the inter-match variability in opposition and match intensity. Whilst there have been few empirical studies, the available data suggests that short-haul travel has minimal effect on physiological and perceptual recovery (e.g. no significant effect on YoYo Intermittent Recovery level 1 test performance), with more regular or longer periods of travel (e.g. 24-h international transfers) more likely to result in negative responses.[15] Whilst short-haul air travel appears to have negligible effects on post-match physiological recovery, the effect on perceptual markers of fatigue and sleep patterns following competition performance is equivocal. If these parameters decline, they can negatively influence training intensity or volume during ensuing sessions due to decreased motivation.[39] Given the myriad of conflicting demands whilst experiencing travel and sleep loss (e.g. treatment, timing of training, recovery practices), it can be difficult for coaches to manage the most appropriate schedule for their team the day after a match. Indeed more research is required to clarify the acute and chronic effects of cumulative travel (e.g. over a season) on sleep and psychological and physiological recovery parameters of professional team-sport athletes.

3.3 Sleep and congested competition schedules

Excessive exercise loads can disturb the stress-recovery balance and result in performance decrements and injury occurrence.[2] For example, during periods of heavy match congestion in soccer, there is an increased injury risk for players when they play two matches per week rather than one.[40] In this regard, English Premier League may compete in up to five competitions at once – which likely impacts on players' sleep behaviour. Congested schedules are also present throughout American sports such as baseball, hockey and basketball. During these periods of high physical workloads, there is a potential for a reduction in sleep duration and quality. For example, it has been shown that as the effects of increased baseball match exposure accumulate towards the end of the season strike zone judgement is impaired, which suggests a fatigue-induced decline in performance; with sleep believed to be one of the main symptoms responsible.[41]

Sleep has also been suggested to be sensitive to exercise overload - with high training volumes associated with greater sleep disruptions.[42] Although no published data is yet apparent in team-sport cases, Netzer et al[43] found significant increases in the REM sleep onset latency and decreases in REM sleep of well trained cyclists following training and a competitive 120-150 km race, compared to no training or competition. Following this, it is logical that when team-sport athletes compete in a greater number of matches within a short period, exercise-induced muscle damage will accumulate (dependant also on exercise intensity), characterised by decreased neuromuscular function, increased perceptual fatigue and increases in perceived soreness which can disrupt sleep.[1] Moreover, if there are several events in short succession, the continual anticipation of competition can also negate sleep.[18] However, at present, there is little research that describes or quantifies the effect of these changes on the subsequent recovery, particularly in team-sports undertaking congested fixture scheduling. Future investigations into the time course of recovery following sleep loss would be particularly pertinent to team sports such as baseball and cricket, since these athletes can play on consecutive days and could be at a high risk of cognitive impairments (e.g. reduction in reaction time).

3.4 Sleep and disturbances to training adaptation

Since sleep loss impedes muscle protein accumulation, the ability of skeletal muscle to adapt and repair can be hindered – which likely limits training adaptations.[3,6,44] This may be concerning during the pre-season for team-sport athletes given sleep disturbances are present during higher training volumes.[42] Since sleep loss can also affect vigour, mood and perceptual awareness,[39] early training sessions could cause reductions in motivation and consequently reduce optimal training performance and subsequent adaptations.[45] Furthermore, if the stress-recovery balance of team-sport athletes is disrupted by either an increase in training load/stress or inadequate recovery, it may lead to an overreached, or even overtrained state.[2] Interestingly, disturbed sleep is believed to be one of many symptoms of either overreaching or the overtraining syndrome.[2] In a recent study by Hausswirth et al[46], it was found that objective measures of sleep duration, efficiency and immobile time were all negatively altered in a group of functionally overreached tri-athletes. There was also a higher prevalence of upper respiratory tract infections within this group, implying an association between the two; however whether impaired sleep and illness occurrence are consequences, or simply symptoms or coincidental associations, of overreaching remains unknown.[46] In light of this, practitioners are encouraged to monitor the sleeping patterns of their athletes in high periods of stress either through subjective sleep diaries and/or wristwatch actigraphy.[5]

Since sleep loss can hinder the learning of new skills, affect emotional regulation and disrupt cognitive function,[6] it is likely that sleep is also important for optimising cognitive training adaptations in team-sport athletes. For instance, sleep is critical for memory retention, neural plasticity, and has been shown to improve visual discrimination and motor adaptation.[22] Therefore, it is likely that disturbing sleep during intense training or skill acquisition periods (e.g. pre-season) will encumber adaption in skill-based tasks with high neurocognitive reliance.[4] However, objective evidence to support this suggestion is not currently present. Therefore, future research (with well controlled randomised-control trials) into the effects of sleep disruption on acute or chronic cognitive-based training adaptations in athletic populations is required.

4. Sleep strategies for team-sport athletes

4.1. Napping

In an attempt to recover from sleep debt, a commonly utilised sleep strategy amongst team-sport athletes is the restorative nap. Naps have been shown to improve alertness, sleepiness, short-term memory and accuracy during reaction time tests.[47] Furthermore, Waterhouse et al[47] found improvements in mean sprint performance following a 30 min post-lunch nap after 4-5 h of sleep restriction. On the basis of this, it has been proposed athletes take a post-lunch nap to ameliorate the performance deficits caused by ultradian biological rhythms that occur within the circadian cycle.[39,47] As such, it appears napping behaviours have many benefits and should be undertaken where necessary in team-sport environments. An example would be for soccer players to have a nap after lunch if they are playing a match at night. However, it is critical that if naps are implemented within a team-sport environment they balance the need to enhance performance whilst not disturbing subsequent sleep patterns, as this could hinder the recovery process following training or competition. Indeed, whilst napping appears advantageous for performance (e.g. napping prior to competition), more research is required to evaluate its possible effectiveness in recovery.

4.2 Sleep extension

Extending sleep during normal sleep times is another strategy to alleviate the decrements in physiological and cognitive performance caused by sleep loss. Mah et al[23] found faster sprint and reaction times and improved shooting accuracy, energy and mood following approximately three weeks of sleep extension (mean + 110 min) in eleven basketball players, indicating its use as a viable option for enhancing team-sport performance. Moreover, extending sleep improves psychological wellbeing thus optimising athletes' mental preparedness for competition.[23] However, obtaining extra sleep can be difficult, because increased sleep onset latency and mood effects can be nullified due to earlier bedtimes. Thus, if an athlete is not sleep deprived it is possible that extending sleep will reap no benefit. The timing of this sleep intervention could also influence the effects of sleep extension depending on the sleep chronotype of the athlete. Additionally, more research assessing whether sleep extension during periods of high-training load is a useful tool to ensure appropriate recovery is required. Such research would be pertinent in assisting players achieve higher sustained intensities in subsequent exercise bouts (i.e. during pre-season).

4.3 Sleep hygiene protocols

Identifying and modifying the factors that contributes to improve sleep quality (improving sleep hygiene) in team-sport athletes can also assist in ameliorating the detrimental effect of sleep loss and potentially enhance recovery. Sleep hygiene strategies have been shown to improve sleep quality and onset latency in university students and reduced sleep irregularity in adolescents, although the effect of numerous components of sleep hygiene in normal sleepers is mixed.[48] From an athletic perspective, little is known about the interaction between these sleep hygiene strategies and the recovery of exercise and psychological parameters. Preliminary evidence indicates adhering to some of the previous sleep hygiene recommendations improves sleep quantity, resulting in a reduction in perceived soreness and fatigue in elite tennis players.[49] Furthermore, regulating sleep-wake times helps synchronise the circadian timing system, improving sleep quality and quantity.[50] As pre-competition worry and anxiety are evident in athletes,[10,18] it may be of benefit to utilise self-confidence tools (i.e. meditation) to manage anxiety and stress, as these correlate with improved sleep.[50] Identifying each individuals best sleep habits (e.g. bed comfort) are also pertinent, as unfamiliar environments may reduce sleep quality.[50] Such recommendations are similar to those designed for team-sport athletes who endure constant travel.[34] It is well known sleep onset is prolonged by noise, light and extreme temperatures, with athletes reporting noise and light as the two most important factors to their sleep quality.[10] Since the use of technology just prior to sleeping promotes afferent signals from the retina to the pineal gland, inhibiting the secretion of melatonin and delaying sleep onset, the avoidance of bedtime technology (and thus reducing arousal and physiological excitement) has been recommended to improve sleep onset.[50] As part of a healthy sleep protocol, several nutritional recommendations have also been proposed to assist with sleep onset. For instance, a recent review by Halson[5] proposed diets high in carbohydrates and protein may result in shorter sleep latencies and improved sleep quality, respectively.[5] Whilst there is a clear need for nutrition during the post-exercise recovery period, the interaction between foods consumed post-exercise and the ensuing sleep and recovery timeline is unclear. Indeed, the effects of nutrition are intricately complex and beyond the scope of this review (see Halson[5] for further detail).

5. Future research

Currently, there is insufficient evidence to conclusively describe the role of sleep for post-exercise recovery and resultant performance outcomes. As such, the first step in understanding this contribution is for the utilisation of long-term observational field studies through the use of subjective sleep diaries and/or actimetry in various situations. This will help to identify areas where sleep may be an issue in team-sport athletes. Once this specific context is known, it is important to understand the interaction sleep has with variables within the high performance athletic environment during situations where sleep is an issue. This requires both randomised-cross over trials which investigate the measurement of sleep and the post-exercise recovery timeline (both physiological and psychological), and also case studies in high performance team-sport athletes. Future work within this field could also focus on understanding the mechanisms involved and providing appropriate interventions to improve sleep and the ensuing recovery process.

6. Practical recommendations for team-sport athletes

The following recommendations (Table 1) are based on the literature within this review. However, the authors recognise that there is a lack of research examining the interactions between sleep and recovery in athletes. Nonetheless, there seems little risk but much (potential) benefit in following these recommendations. It is perhaps most important to tailor interventions toward individual athletes.

INSERT TABLE ONE

7. Conclusion

While sleep is commonly reported to be critical for recovery from intense exercise and/or competition by athletes, coaches and scientists, the current understanding of the effect of sleep on the recovery profile, especially in athletic populations, remains unclear. There is evidence to suggest elite athletes lose sleep prior to and during competition periods. Further, although limited published data is available, team-sport athletes appear to be susceptible to reductions in sleep quality and duration during and following competition (especially at night), during periods of congested fixture scheduling and following longer forms of travel. Given the regularity at which numerous professional teams might encounter these situations throughout a season, they may encumber the players sleep and recovery. The efficacy of interventions to improve sleep, such as sleep hygiene protocols and sleep extension appear advantageous - but require further investigation in situations relevant to professional team sports. These interventions may be suited to specific situations when the risk of compromised sleep is higher (i.e. playing at home or away, at night and/or inclusive of travel). This is especially pertinent with regards to the recovery of exercise parameters. Indeed, since research in this area is lacking, further research into the role of sleep and recovery in team sports is warranted.

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FIGURE CAPTIONS

Figure 1: The increase in the number of sleep, athlete and recovery publications over the past eight years. The solid fill lines illustrate the amount of literature which appears following a Pub Med database search using the terms “sleep”, “recovery” and “athlete” in all fields for each calendar year.

Figure 2: A schematic representation of the commonly encountered situations in team sports which may compromise sleep patterns and potentially recovery. Theoretical effects of these situations are also described; however it should be noted more research is required to confirm the majority of these effects.