

The influence of training and competition on sleep behaviour of soccer referees

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RUNNING HEAD: SLEEP BEHAVIOUR IN SOCCER REFEREES

Key words: sleep, actigraphy, sports officials, team sport,

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Abstract

The aims of the present study were to (1) quantify sleep behaviours of soccer referees and (2) compare sleep behaviours between nights before training, before matches, and after matches. Fourteen professional soccer referees from the A-League (mean±SD; age 34±4 years; sex: 11 males, 3 females) participated in this observational study. Referees' sleep behaviours were examined using sleep diaries and wrist activity monitors for 31 consecutive nights during the 2018-2019 A-League season. Separate linear mixed models were conducted to assess differences in sleep behaviours between nights before training, before matches, and after matches. Referees went to bed later, spent less time in bed, and slept significantly less post-matches compared to pre-training and pre-match nights ($p<0.05$). No differences in sleep quality were observed between nights as indicated by sleep efficiency, sleep onset latency, wake in sleep, and movement fragmentation index. On average referees did not obtain recommended sleep durations across the in-season (mean±SD sleep duration: 6.4 h ± 0.7 h). Referees were particularly susceptible to inadequate sleep on nights following training and matches. The findings related to poor sleep behaviours highlight the importance of implementing monitoring systems to understand the sleep behaviours of referees, with further research encouraged to ascertain the efficacy of various sleep hygiene practices to optimise sleep in this population.

Keywords: sleep, A-league, sporting official, competition,

Introduction

Obtaining adequate sleep duration and quality are important for optimal athletic performance (Roberts, Teo, Aisbett, & Warmington, 2019). In part, the need for adequate sleep relates to both the recovery from previous fatigue-inducing training or competition, as well as physical and cognitive preparation for ensuing bouts. In professional football (soccer), extensive attention has focussed on reporting the duration and quality of sleep obtained by players to understand their sleep behaviour and in turn, examine the efficacy of sleep interventions (Fowler, Duffield, Howle, Waterson, & Vaile, 2015; Nedelec, Halson, Abaidia, Ahmaidi, & Dupont, 2015; Pallesen et al., 2017). However, there is a lack of research examining the sleep behaviour of soccer referees and adjudicating officials more generally, which is surprising given they share similar demands to the players they officiate. Thus, investigation into the sleep behaviours of referees is pertinent given competitive soccer matches evoke extensive physical and cognitive demands on referees, who must make frequent decisions that can affect match outcomes (Castagna, Abt, & D'Ottavio, 2007).

The restorative processes resulting from sufficient sleep are likely important for soccer referees given the high physical and mental stress encountered during matches (Castagna, Abt, & D'Ottavio, 2004). For example, the match demands of soccer referees involve high physical workloads (≈ 11 km per match, including up to ≈ 0.9 km of high-speed running (at >19.0 km·h⁻¹), and prolonged cardiovascular strain (i.e. mean heart rate of >170 bpm) (Castagna et al., 2004). Further, referees endure high perceptual-cognitive stress during matches, with up to 137 observable critical and time-limited decisions per match, equating to 1.5 decisions every minute (Castagna et al., 2007; MacMahon, Helsen, Starkes, & Weston, 2007; Weston et al., 2012). Given the negative influence of poor sleep on physical performance and decision-making performance in adults (Belenky et al., 2003; Smith et al., 2019), establishing the sleep behaviours of professional soccer referees during the in-season is important to identify whether

any sleep deficiencies are encountered that may affect their preparedness for, and recovery from competitive matches.

Despite no current sleep duration or quality data being reported in soccer referees, sleep durations after night matches are compromised in soccer players (Fullagar, Skorski, Duffield, & Meyer, 2016). Given the similar contextual circumstances faced by soccer players and referees for matches (e.g., competition schedules, post-match reviews, travel requirements, hotel accommodation,), it is assumed scheduling and match-induced physical and perceptual stress would similarly constrain sleep quantity and quality in players and referees (Castagna et al., 2004). Examining a broad range of referees from different sports, including soccer, Vincent et al. (2020) found that referees reported less sleep the night after compared to the night before competition. While a single night of partial sleep restriction may not have detrimental effects on recovery, psychological well-being or subsequent performance (Franco-Wilke et al., 2020), cumulative sleep disruption may decrease reaction time and decision-making capacity, which are important for referee performance (Van Dongen, Maislin, Mullington, & Dinges, 2003). Despite providing insight on sleep behaviours of referees pooled from various sports, Vincent et al. (2020) used retrospective recall of sleep behaviours and did not isolate findings for soccer referees based on their training and competition schedules.

Accordingly, objective sleep data are needed to accurately identify the duration and quality of sleep that soccer referees obtain during training and matches. In turn, articulating if and when sleep is impaired in soccer referees across the in-season can aid development of strategies targeted at improving sleep practices to optimise performance and health in this population. Therefore, the aims of the present study were to (1) quantify the in-season sleep behaviours of soccer referees and (2) compare sleep behaviours between nights before training, before matches, and after matches.

Methods

Participants

Fourteen professional soccer referees voluntarily participated in this study (mean age \pm standard deviation, *SD*): 34 ± 4 years; sex: 11 males, 3 females). Referees were recruited from Football Federation Australia and officiated in the highest-level of professional Australian soccer (A-League) competition. Of note, not all were full-time referees, with most having substantial employment external to refereeing duties. Referees were provided with written and verbal information regarding the purpose, risks, and benefits of the study before written informed consent was obtained. The study was approved by the Central Queensland University Human Research Ethics Committee (0000021488).

Study Design

An observational study design was adopted where data were collected for 31 nights (March 1st – 31st 2019) during one month of the 2018-2019 A-League season requiring oversight of professional domestic competitions and travel within Australia. During the data collection period, referees completed a daily self-report sleep diary and wore an activity monitor (Actical, MiniMitter, Philips Respironics, Bend, OR, USA). Referees officiated a minimum of one match (scheduled start times ranged between 16:30 – 19:30 hh:mm) throughout the data collection period. On days between matches, referees attended training and recovery sessions as per their normal schedule that were not manipulated by the research team. A total of 26 matches were monitored during the data collection period. There were 10 matches where referees slept interstate (in a hotel room), with referees sleeping at their individual homes for all other matches. To examine the impact of matches on the sleep behaviour of referees, sleep periods were characterised as either: (1) before a training day (pre-training); (2) before a match (pre-match); or (3) following a match (post-match).

Sleep Assessment

Sleep behaviour was monitored in each referee using self-report sleep diaries and wrist activity monitors (Actical Z-series; Philips Respironics, Oregon, USA). Data derived from the sleep diaries and wrist activity monitors were used to determine the duration and quality of sleep obtained. All time was scored as wake unless: (1) the sleep diary indicated the referee was lying down attempting to sleep and (2) the activity counts derived from the activity monitor were sufficiently low to indicate the referee was immobile. When these two conditions were met simultaneously, time was scored as sleep. This scoring process was conducted using Phillips Respironics' Actiwatch algorithm with sensitivity set at 'medium' (Weiss, Johnson, Berger, & Redline, 2010). This algorithm has previously been used to quantify sleep behaviour in elite athletes (Lastella, Roach, Halson, Martin, et al., 2015; Lastella, Roach, Halson, & Sargent, 2015). The sleep-related dependent variables extracted from sleep diaries and activity monitors are described in Table I.

insert Table I

Statistical Analyses

All data are reported as mean \pm SD. Data were analysed using a general linear mixed model with the R package lme4 (R Core Team 2016). The effect of condition (i.e., training, pre-match, or post-match) on each dependent variable was examined with “condition” specified as a fixed effect and “participant” entered as a random term. The statistical significance of all fixed effects was determined using F tests. When necessary, Bonferroni corrections were made to reduce the change of obtaining a type 1 error. Statistical significance was determined with alpha set at <0.05 .

Results

From the recorded data, 322 nights were monitored across the 14 participants (mean \pm SD nights of data; 23.0 ± 5.1). As descriptive context, referees obtained <7 h of sleep on 187 out of 268 nights prior to training (70%), 13 out of 29 nights before matches (45%), and 18 out of 25 nights immediately following matches (72%). The distribution of nightly sleep duration is presented in Figure 1.

insert Figure 1

Sleep data including the effects of condition (i.e. pre-training, pre-match, and post-match nights) are presented in Table II. Individual data points for bedtime, get up time, time in bed, total sleep time, sleep onset latency, wake in sleep, sleep efficiency, and movement fragmentation index as a function of condition in referees are presented in Figure 2. Linear mixed models revealed significant differences in bedtime ($p < 0.001$), get up time ($p = 0.009$), time in bed ($p = 0.003$), and total sleep time ($p = 0.004$) between conditions (Table II). Post-hoc comparisons revealed referees went to bed later, spent less time in bed, and slept less post-match compared to pre-training and pre-match nights ($p < 0.05$) (Table 2). Further, get up times

following matches were later compared to get up times on pre-training days ($p < 0.05$). No significant differences existed between pre-training, pre-match, and post-match nights for sleep efficiency ($p = 0.95$), sleep onset latency ($p = 0.37$), wake in sleep ($p = 0.14$), and movement fragmentation index ($p = 0.85$).

insert Table II

insert Figure 2

Discussion

The aims of the present study were to (1) quantify the in-season sleep behaviour of soccer referees and (2) compare sleep behaviour between nights before training, before matches, and after matches. The main findings show that (1) matches delay subsequent bedtime as well as reduce subsequent time in bed and sleep duration without commensurate changes in get up time and (2) despite nights before training resulting in the most favourable sleep behaviours and durations, they remain less than recommended guidelines (i.e. < 7 h on 70% of all nights before training). Accordingly, these results indicate greater attention on sleep behaviours in soccer referees may be needed to optimise referee preparation for upcoming matches as well as recovery from matches.

A concerning finding in the present study was that soccer referees obtained less than 7 hours of sleep on 68% of nights throughout the monitoring period; particularly before training (70% of nights) and immediately after competition (72% of nights). Although evidence on the amount of sleep required to maintain optimal athletic performance is equivocal (Sargent, Lastella, Halson, & Roach, 2014), national guidelines and ecological data collected in professional soccer players indicate sleep durations > 7.0 hours per night to be preferable (Lastella, Roach, Halson, & Sargent, 2015; Lastella, Roach, & Sargent, 2019). Accordingly, the soccer referees examined in the present study showed consistently less sleep per night (≈ 30 min, i.e. 6.5 ± 1.1 h) than recommended guidelines. In part, this finding is explained by the

later bedtimes and earlier get up times observed in this cohort of referees, which suggests some element of behaviour patterns leading to the poor sleep outcomes (Juliff, Halson, & Peiffer, 2015). Without comparative data in soccer referees, it may be reasonable to compare the present findings to data reported in players which is more readily available. In this regard, the present data suggest referees may experience reduced sleep durations and time in bed compared to similar research examining professional soccer players (Lastella, Roach, Halson, & Sargent, 2015; Lastella et al., 2019). Differences in professional status and salary between professional soccer players and referees may underpin this finding; such that the majority of professional referees in Australia are not full-time employees and have to supplement their roles with full-time work outside of soccer. Thus, sleep behaviours as a result of lifestyle-related factors such as other work commitments may explain the lower sleep duration noted on any given training day in referees.

Similar to professional soccer players, post-match sleep remains a key issue for soccer referees to undergo necessary physical and mental recovery. Evidence of the negative effects of night competition on subsequent sleep in soccer players is common, with significantly reduced time in bed and sleep durations compared to training nights (Fullagar et al., 2016; Lastella et al., 2019). For example, Fullagar et al. (2016) revealed soccer players slept ≈ 3 hours less the night following competition (5.6 ± 1.6 h) compared to a training night (8.7 ± 0.7 h). Likewise, soccer referees in the present study obtained 5.9 ± 1.4 hours of sleep the night following competition, which was ≈ 36 minutes less compared to the night before training. Of interest, this difference between post-training and post-match sleep duration is smaller than that reported in players (Lastella et al., 2019). An obvious explanation is that the amount of sleep referees obtained before training or matches were already below the recommended 7 to 9 hours of sleep per night (Hirshkowitz et al., 2015), and hence the post-match sleep duration change was smaller than that reported in players. Whether this finding suggests a chronic concern of reduced sleep

attainment in soccer referees remains speculative and requires future longitudinal evidence. In this regard, while the effects of a single night of partial sleep restriction may not have detrimental effects on recovery, psychological well-being, or subsequent performance (Franco-Wilke et al., 2020), the cumulative effects of consistently obtaining less than 7 hours of sleep per night may have detrimental cognitive effects, such as reduced reaction time and decision-making capacity, which are important for referee performance during matches (Van Dongen, Maislin, Mullington, & Dinges, 2003).

Sleep quality as inferred from sleep efficiency, sleep onset latency, and movement indices revealed no differences between pre-training, pre-match, and post-match nights. Previous data examining these sleep indices in professional soccer players are comparable to the current findings in that similar sleep efficiency (e.g. 85 – 87%), sleep onset latency (9 – 14 min), and the amount of time spent moving during sleep (≈ 1.2 h) are similar between referees and soccer players (Lastella, Roach, Halson, & Sargent, 2015; Lastella et al., 2019; Miller et al., 2017). Accordingly, it seems the “quality” of sleep obtained by referees is commensurate with players, and reinforces the aforementioned concerns about sleep quantity and behaviour outlined earlier. Of note, it is important to recognise the limitations when interpreting actigraphy-based sleep quality data given its dependence on self-reported bedtime rather than individual actual sleep.

Given this is the first study to objectively examine sleep patterns of soccer referees, comparisons with past research, specifically on referees, are difficult to make. However, a previous study utilised self-reported sleep measures to determine after the impact of competition on sleep in a broad group of referees from different sports, including soccer (Vincent et al., 2020). Similar to the findings of the current investigation, Vincent et al. (2020) demonstrated that sporting officials reported obtaining considerably less sleep the night immediately after competition compared to before competition, assumingly due to reduced

time in bed. In this regard, there are several plausible explanations for later bedtimes following competition in referees reported in the present study. Comparable to players, referees may engage in post-competition assessment, recovery, medical evaluation, and press conferences which may delay bedtime (Fullagar et al., 2016). Further, all competition adjudicated by the referees in the present study occurred either in the late afternoon ($\approx 16:30$) or early evening ($\approx 19:00-19:30$), meaning referee duties ceased between $\approx 18:30$ and $\approx 21:30$. The timing of exercise cessation may have interfered with the psychological and physiological changes that help prepare the body for sleep across these timeframes (Miller et al., 2019). For example, the physiological response of an elevated core body temperature following exercise may delay sleep onset given human circadian rhythms of core body temperature and sleep are closely related such that the onset of sleep has been associated with the evening decline in core body temperature (Driver & Taylor, 2000; Murphy & Campbell, 1997). Likewise, rumination over performance, psychological arousal, and elevated stress responses may also induce poorer sleep following competition (Fuller, Waters, Binks, & Anderson, 1997; Juliff, Peiffer, & Halson, 2018; Vincent et al., 2020).

Limitations

Given this was an applied, field-based study, there are some limitations that need to be acknowledged. This study was conducted in a small number of professional soccer referees from Australia ($n=14$). The findings cannot be generalised to other sports or potentially to other leagues where the demands imposed on soccer referees and scheduling of competition may differ. Future research could include participants from soccer leagues across the world to increase study sample sizes. Second, there were only three female referees represented in the present sample, restricting any comparison in sleep behaviours between sexes, it is possible that males and females may be influenced by different contextual factors which could subsequently impact sleep opportunities. Third, the physical demands during training and

matches were not quantified and therefore could not be factored into analyses. Finally, the number of nights of data collected during training compared to competition was substantially higher. While it is understood that competition scheduling dictates the amount of matches played (e.g. typically once a week), examining sleep for longer than a month would have captured more samples on the nights before and after competition, and is encouraged in future investigations.

Practical Implications

The high prevalence of referees obtaining less than 7 hours of sleep across the in-season suggest that sleep behaviour and interventions require attention for surrounding training and competition. In this way, the introduction of validated commercial sleep devices (e.g. Fitbit, Whoop) to objectively assess the timing and duration of sleep obtained by soccer referees may be a practical strategy for managerial staff to better understand and identify problems in the sleep behaviours of referees employed in their competition (Halson, 2019). Further, maximising recovery and sleep opportunities across the season should be targeted, with individualised sleep hygiene education sessions targeted to establish regular bed and wake times, increase sleep duration and facilitate favourable schedules surrounding both training and competition in soccer referees (Driller, Lastella, & Sharp, 2019).

Conclusions

This is the first study to objectively measure sleep behaviours in soccer referees, demonstrating referees typically do not obtain recommended sleep durations across the in-season, being particularly susceptible to inadequate sleep on nights following training and matches. Referees went to bed later, spent less time in bed, and slept significantly less post-match nights compared to pre-training and pre-match nights, though sleep quality did not differ. Accordingly, further research is encouraged on this topic examining the impact of contextual factors (e.g. workloads,

crowd size, match location, travel) on sleep in professional soccer referees as well as expanding the sample recruited to encompass more female referees and referees from other football confederations for more comprehensive analysis.

Acknowledgement

The authors would like to thank the Football Federation Australia and the referees who took part in the study.

Disclosure Statement

No potential conflict of interest was reported by the authors.

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