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Travel fatigue and sleep/wake behaviors of professional soccer players during international competition

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ABSTRACT

Objective: The magnitude of travel completed by professional Australian soccer teams during domestic competition is substantial. The inclusion of Australian soccer teams into the Asian Champions league has seen additional stress placed on soccer players' training and competition schedules. For management staff, the complexity of organizing training and travel schedules during domestic competition and the Asian Champions league is challenging.
Design: Case study.
Participants: Seven male professional soccer players (mean $\pm$ SD: age 25.2 $\pm$ 3.2 years, height 182.8 $\pm$ 5.2 cm, body mass 84.6 $\pm$ 7.4 kg).
Measurements: This study examined the sleep and fatigue levels of Australian soccer players during an intensive home and away travel schedule during the Asian Champions league. Seven male professional soccer players' (mean $\pm$ SD: age 25.2 $\pm$ 3.2 years, height 182.8 $\pm$ 5.2 cm, body mass 84.6 $\pm$ 7.4 kg) sleep/wake behavior was assessed using sleep diaries and wrist activity monitors for 19 days, including 9 days before, 5 days during, and 4 days after a home and away group stage match of the Asian Champions league. Analyses examined differences in sleep/wake behavior and fatigue levels between day type (training day, rest day, pregame, and postgame) and between sleep location (Adelaide, during flight, and Hiroshima).
Results: Sleep/wake behavior and fatigue levels were poorest the night immediately after games compared to the night before games, training days, and rest days. Soccer players' sleep/wake behaviors were disrupted during flights such that they obtained 3.6 hours less sleep during flights compared to sleep in Adelaide (7.0 $\pm$ 1.6 hours) and Hiroshima (7.0 $\pm$ 2.1 hours).
Conclusion: The sleep/wake behaviors of professional soccer players are compromised when they are required to travel and compete in multiple matches within a short period of time.

Introduction

Since the inclusion of Australia into the Asian Football Confederation, Australian A-League teams are able to qualify and compete in the Asian Champions League. The Asian Champions League is a premier club tournament in Asia where a total of 32 professional soccer clubs compete in the competition. In Australia, the Asian Champions League schedule coincides with the domestic competition. This places additional stress on professional soccer players' training and competition schedules. Therefore, the planning of travel, the management of training, recovery, and domestic competition is critical.

Australian domestic teams are required to travel to all parts of Asia to compete in the Asian Champions League. Although this represents between 2 and 3 clubs per Asian Champions League campaign, it becomes particularly relevant for these teams toward the end of season where matches may be deemed more important when compared to the beginning of the domestic season. In some circumstances, teams are required to travel long distances across multiple time zones (eg, long-haul transmeridian travel), whereas in other circumstances, teams travel long distances with minimal time zone disruption (eg, long-haul travel). There are also some circumstances where teams travel shorter distances (eg, short-haul travel, <5 hours) with minimal to no time zone disruption.

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Short-haul air travel for away matches is common for soccer teams during the season.[1] The effects of short-haul air-travel (<5 hours) on performance and physiological responses are equivocal[2–4]; no differences have been identified for strength, power, or objective sleep quality before and after short-haul air travel.[3–5] On the contrary, the adverse effects of long-haul transmeridian travel in elite athletes are well established.[6–8] Following transmeridian travel, athletes experience jet lag, which manifests itself in symptoms of fatigue, insomnia, daytime sleepiness, and impaired alertness.[2,9] This is typically a result of the misalignment between the internal body clock and the external environment.[10]

In circumstances where minimal or no change in time zones occur, athletes may experience travel fatigue. Travel fatigue may be a result of being in a confined space for a long period of time, with restricted movement, and exposure to dry air possibly causing dehydration. Consequently, athletes may have difficulty sleeping during their flights and arrive at their destination in a fatigued and sleep deprived state.[11]

The magnitude of travel completed by professional soccer teams during a season is substaintial. For example, during the competitive season, soccer teams are required to travel 26 times (including outbound and return travel), traveling up to 3500 km during each flight.[12] For soccer teams competing in the Asian Champions League, the traveling distance may increase up to 11,035 km per flight and may be further broken up into multiple flights and/or bus and train trips. Consequently, the complexity of organizing professional soccer players training and travel schedules during the Asian Champions League competition is challenging. The purpose of the present study is to examine the sleep and fatigue levels of soccer players during an intensive home and away travel schedule during Australian domestic season and the Asian Champions League.

Methods

Participants

Originally, 10 soccer players were recruited to participate; however, 3 data sets were incomplete because of injury and final squad selection. Seven male professional soccer players (mean ± SD: age 25.2 ± 3.2 years, height 182.8 ± 5.2 cm, body mass 84.6 ± 7.4 kg) representing a team competing in the Asian Champions League volunteered to participate in the study. Prior to data collection, participants provided written informed consent. This study was approved by the human research ethics committee of the University of South Australia.

Design

Data were collected for a total 19 days before, during, and after a home and away group stage match of the 2010 Asian Champions League (Fig. 1). The training of each participant was controlled and monitored for the duration of the study using a training diary. For the first 9 days of the data collection period, participants slept at home in their usual sleeping environment. On day 10, participants flew to Fukuoka, Japan, via Singapore. After which, participants took a bullet train from Fukuoka airport to Hiroshima. In Hiroshima (study day 11), participants stayed in a 5-star hotel (2 players per room) for 5 days before returning to Adelaide via Singapore. Data were collected for 4 days after returning home. Participants were instructed to wear their activity monitor and record their bed and get-up times in a self-report sleep diary for the duration of the 19-day data collection period. Participants were asked to record their bedtime and presleep fatigue prior to a nighttime sleep period and their get-up time, postsleep fatigue, and sleep quality as soon as practicable after waking. The participants were instructed not to remove their activity monitor except when showering/swimming or during training and games.

Travel

The trip from Adelaide, Australia, to Hiroshima, Japan, required a 1.5-hour eastward time zone change between Adelaide (UTC +10.5 hours) and Hiroshima (UTC +9.0 hours). The first leg was from Adelaide, Australia, to Changi, Singapore (flight departure time = 13:05; travel duration = 7.5 hours; distance = 5403 km). In Singapore, players had a 9.6-hour layover before the next flight to Fukuoka, Japan. The second leg was from Changi to Fukuoka (flight departure time = 01:05; travel duration = 7.0 hours; distance = 4526 km). The final leg was a bullet train from Fukuoka to Hiroshima (train departure time = 09:00; travel duration = 1.5 hours; distance = 282 km).

Training and competition schedule

Training sessions conducted in Adelaide, Australia, commenced at 10:00 local time, whereas training sessions in Hiroshima, Japan, commenced at 16:00 local time. The first group match held in Adelaide, Australia, commenced at 19:00 (study day 8), and the return match in Hiroshima, Japan, commenced at 19:30 (study day 14).

Measures

Participants' sleep/wake behavior was monitored using self-report sleep diaries and wrist activity monitors (Philips Respironics, Bend, OR). Data derived from the sleep diaries and wrist activity monitors were used to determine the amount and quality of sleep participants obtained. All time was scored as wake unless (1) the sleep diary indicated the participant was lying down attempting to sleep and (2) the activity counts derived from the activity monitor were sufficiently low to indicate that the participant was immobile (ie, where the weighted activity count for an epoch fell below the defined threshold).[13] In this study, the scoring process was conducted with a sensitivity set at "medium" which corresponds to a threshold activity count of 40.[14] Once these conditions were met simultaneously, time was scored as sleep. This algorithm has been most recently been used to quantify the sleep/wake behavior in elite athletes.[15,16] The following sleep variables were extracted from the activity monitors and sleep diary data:

- *Bedtime (hh:mm):* the self-reported clock time at which a participant went to bed to attempt to sleep.
- *Get-up time (hh:mm):* the self-reported clock time at which a participant got out of bed and stopped attempting to sleep.

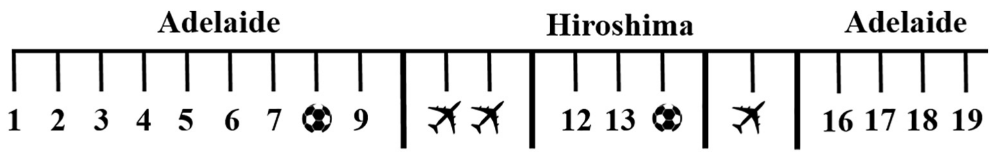

Fig. 1. Schematic outline of the study design including the timing of travel and games.

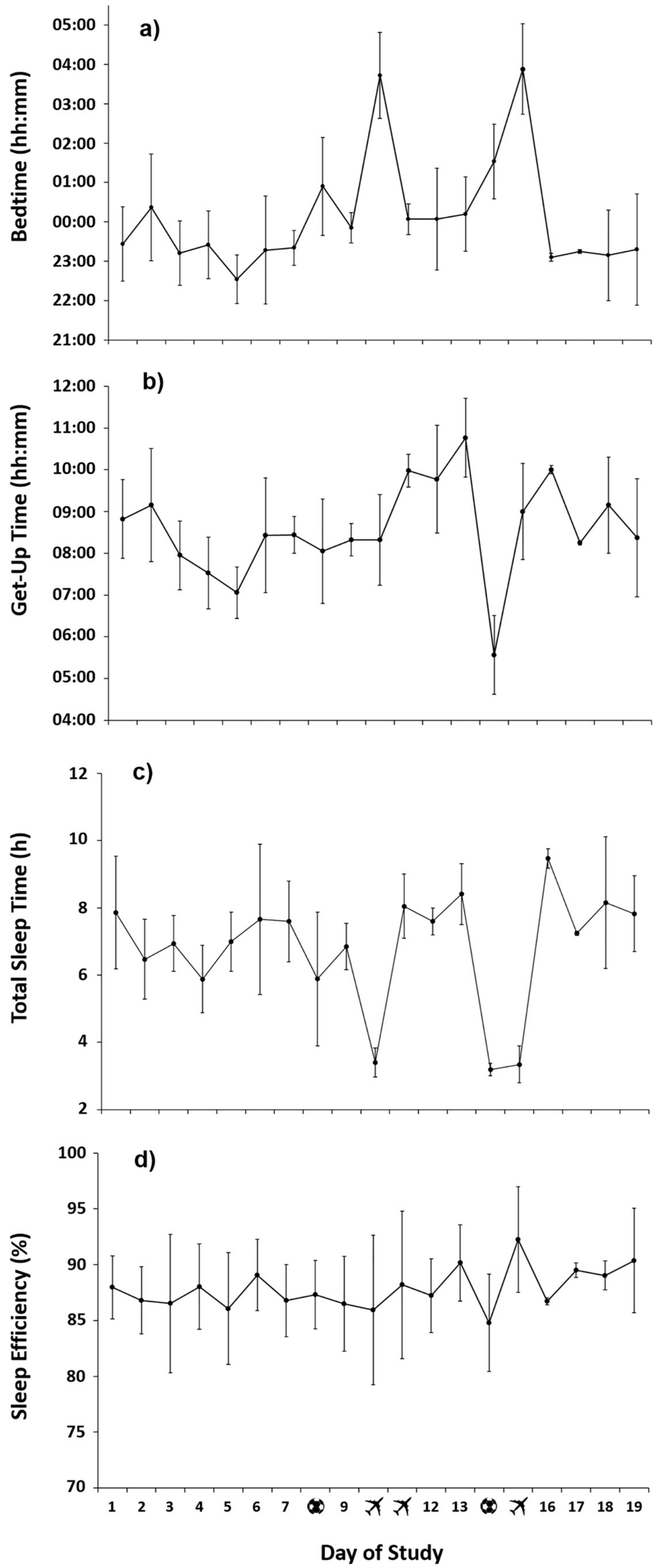

Fig. 2. Bedtime (a), get-up time (b), total sleep time (c), and sleep efficiency (d) during data collection. The black line represents the mean (SD) bedtime, get-up time, total sleep time, and sleep efficiency of athletes. Note: The soccer ball represents the night of a game, and the airplane represents days where travel took place.

- *Sleep latency (min):* the period of time between bedtime and sleep onset time.
- *Time in bed (h):* the amount of time spent in bed attempting to sleep between bedtime and get-up time.
- *Total sleep time (h):* the total amount of sleep obtained during a sleep period.
- *Sleep efficiency (%):* the percentage of time in bed that was spent asleep.
- *Moving minutes (min):* the amount of time spent moving during time in bed.
- *Subjective sleep quality:* the participants' self-rating of sleep quality on a 5-point Likert scale of 1 (very good) to 5 (very poor).
- *Daytime nap duration (min):* the total amount of sleep obtained during a daytime nap.
- *Presleep fatigue level:* the participants' self-rated level of fatigue prior to sleep onset recorded on a scale of 1 (fully alert, wide awake) to 7 (completely exhausted, unable to function effectively).
- *Postsleep fatigue level:* the participants' self-rated level of fatigue prior to sleep onset recorded on a scale of 1 (fully alert, wide awake) to 7 (completely exhausted, unable to function effectively).

Statistical analyses

Descriptive analyses of participants' sleep/wake behaviors were conducted. These analyses were based on sleep periods that were sampled from participants for training days, rest days, pregame days, and postgame days. Figs. 2 and 3 show the time course changes in sleep/wake behavior across the duration of the study.

To examine the impact of night matches on the sleep/wake behavior of professional soccer players, sleep periods were characterized as 1 of 4 types: (1) a sleep period that preceded a training day; (2) a sleep period that preceded a rest day; (3) a sleep period that immediately preceded a night match; and (4) a sleep period that immediately followed a night match. The effect of day type (ie, training day, rest day, prematch, or postmatch) on each dependent variable was examined using linear mixed-effects models, with "day type" specified as a fixed effect and "participant" entered as a random term.

To examine the impact of sleep location on the sleep/wake behavior of professional soccer players, sleep periods were characterized as 1 of 3 types: a sleep period in Adelaide, Australia; on a flight; or in Hiroshima, Japan. The effect of sleep location (ie, Adelaide, flight, or Hiroshima) on each dependent variable was examined using linear mixed-effects models, with "sleep location" specified as a fixed effect and "participant" entered as a random term.

All results are reported as mean ± SD. The statistical significance of all fixed effects was determined using F tests. Bonferroni corrections were made to reduce the chance of obtaining a type 1 error. Data were analyzed using SPSS (v23.0) statistical software. The statistical significance of all fixed effects was determined using the conventional significance set at $P < .05$.

Results

Sleep/wake behavior

On average during training and rest days in all locations, participants went to bed at 23:38 ± 01:00, took 10.2 ± 13.2 minutes to fall asleep, spent 8.6 ± 1.6 hours in bed, obtained 7.2 ± 1.5 hours of sleep, and got up at 08:35 ± 01:29. Sleep efficiency was 87.8% ± 4.3%, and participants rated their subjective sleep quality as "good" (1.9 ± 0.8 units). Participants reported feeling "moderately tired" before sleep (4.7 ± 0.9 units) and "somewhat fresh" after waking from sleep (2.9 ± 1.2 units).

Napping behavior

Six participants reported napping during the data collection period. On average, these naps were taken at 15:00 ± 02:36, where participants took 12.5 ± 12.5 minutes to fall asleep, obtained 55 ± 36 minutes of sleep, had a sleep efficiency of 88.3% ± 4.0%, and rated their sleep quality during these naps as "average" (2.7 ± 1.0). Participants reported feeling "moderately tired" before sleep (5.0 ± 1.0 units) and "a little tired, less than fresh" after waking from sleep (3.7 ± 1.0 units).

The effect of day type on sleep/wake behavior

Linear mixed-effects models revealed a significant main effect of day type on bedtime ($F_{3,69} = 7.2$, $P = .000$), time in bed ($F_{3,67} = 8.4$, $P = .000$), total sleep time ($F_{3,67} = 7.6$, $P = .000$), presleep fatigue ($F_{3,63} = 5.7$, $P = .002$), and get-up time ($F_{3,69} = 4.6$, $P = .005$. Bedtime was later the night immediately following night matches compared to any other condition (Table 1). Get-up times were earliest the morning immediately following games compared to rest days

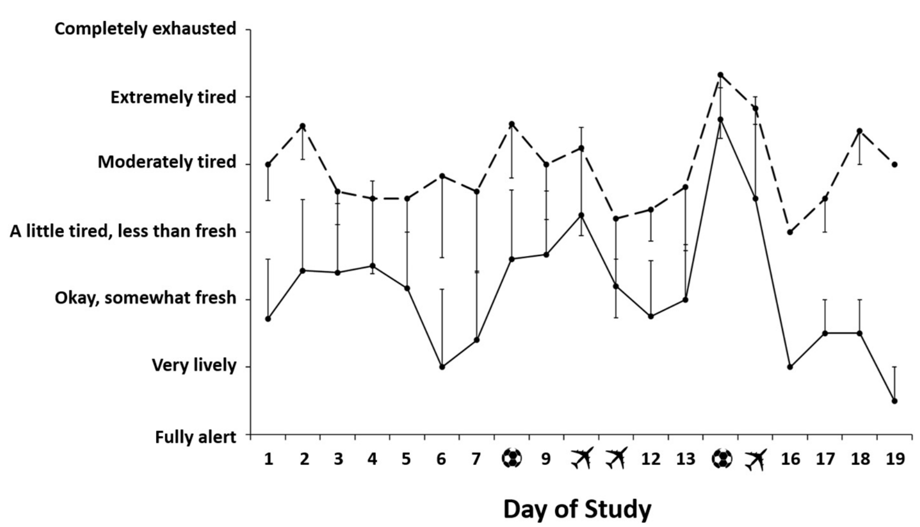

Fig. 3. Pre- and postfatigue levels during data collection. The black dotted line represents the mean (SD) for presleep fatigue and the black line postsleep fatigue levels. Note: The soccer ball represents the night of a game, and the airplane represents days where travel took place.

Table 1
Sleep/wake behavior as a function of type of day.*

Characteristic	Type of day			
	Training (mean ± SD)	Rest (mean ± SD)	Pregame (mean ± SD)	Postgame (mean ± SD)
Bedtime (hh:mm)*	23:35 ± 01:00[a]	23:04 ± 01:10[b]	23:46 ± 00:54[c]	01:46 ± 01:03[a,b,c]
Get-up time (hh:mm)*	08:13 ± 01:24	09:20 ± 01:16[a]	09:21 ± 01:44[b]	07:30 ± 01:26[a,b]
Sleep latency (min)	12.3 ± 16.6	8.1 ± 10.4	10.3 ± 17.4	5.0 ± 7.3
Time in bed (h)*	8.3 ± 1.7[a]	9.0 ± 1.4[b]	9.3 ± 1.5[c]	5.5 ± 2.1[a,b,c]
Total sleep time (h)*	7.0 ± 1.6[a]	7.6 ± 1.3[b]	7.9 ± 1.2[c]	4.5 ± 1.9[a,b,c]
Sleep efficiency (%)	87.8 ± 4.7	87.6 ± 2.9	88.0 ± 3.9	84.5 ± 3.3
Movement and fragmentation index (units)	31.4 ± 10.7	32.5 ± 9.1	32.6 ± 9.0	33.5 ± 9.9
Presleep fatigue (units)*	4.7 ± 0.9[a]	5.0 ± 1.9	4.6 ± 1.1[b]	6.0 ± 1.0[a,b]
Postsleep fatigue (units)	3.1 ± 1.3	3.2 ± 1.0	2.5 ± 1.1	4.3 ± 1.3
Subjective sleep quality (units)	2.0 ± 0.8	1.7 ± 0.7	2.1 ± 1.0	3.2 ± 1.2

* Significant main effect. Mean values with the same superscript are significantly different ($P < .05$).

and the morning preceding games (Table 1). Time in bed and total sleep times were shorter the night immediately following night matches compared to any other condition (Table 1). Pre- and postsleep fatigue was highest immediately following night matches compared to training days and nights preceding games (Table 1). There were no significant differences between day type for sleep latency, sleep efficiency, movement and fragmentation index, postsleep fatigue, or subjective sleep quality ($P =$ not significant).

The effect of location on sleep/wake behavior

Linear mixed-effects models revealed a significant main effect of location type on bedtime ($F_{2,27} = 39.6$, $P = .000$), time in bed ($F_{2,32} = 13.7$, $P = .000$), and total sleep time ($F_{2,31} = 13.1$, $P = .000$). Bedtimes were significantly later during flights compared to bedtimes in Adelaide or Hiroshima (Table 2). There were no significant differences in get-up time, sleep latency, sleep efficiency, presleep fatigue, postsleep fatigue, movement and fragmentation index, or subjective sleep quality between sleep locations ($P =$ not significant).

Discussion

The present study examined the sleep/wake behavior of professional soccer players during the 2010 Asian Champions League campaign. The 3 main findings were as follows: (1) soccer players slept more than 7 hours per night during a typical training week; (2) competitive matches resulted in considerably poorer sleep/wake behaviors compared to training and rest days; and (3) sleeping on flights caused significant disruptions to the timing and amount of sleep obtained by professional soccer players.

Amount of sleep obtained by professional soccer players

Although there is no general consensus regarding the amount of sleep an elite athlete must obtain to maintain optimal performance,[17] data have shown that athletes who obtain less than 8 hours of sleep per night have an increased likelihood of obtaining an injury.[18] Further, data from studies examining the sleep of elite athletes indicate that most athletes obtain between 6.1 and 7.5 hours of sleep per night.[15,17,19] There also appears to be a difference between type of sport, as athletes from individual sports tend to have shorter sleep durations than athletes from team sports.[15]

After excluding sleep on travel days and after night matches, professional soccer players obtained an average of 7.2 hours sleep per night. When compared to other studies that have examined the sleep/wake behavior of soccer players, the results of this study are similar. For example, Fullagar et al[20] and Roach et al[13] reported average sleep durations of 6.9 hours and 7.0 hours per night for semiprofessional and elite youth soccer players, respectively. These sleep durations represent data during a training week which excludes various circumstances shown to disrupt the sleep of elite athletes such as competition,[16,21] transmeridian travel, and altitude exposure.[2,13,22] Given the consistency across studies examining sleep during a typical training week, it is evident that when soccer players are free from competition and travel demands, they obtain more than 7 hours of sleep per night.

Impact of night matches on soccer players' sleep

The impact of night games on subsequent sleep is well established.[20,23] For example, Sargent and Roach (2016) examined the sleep of elite Australian football players on the night immediately following a day game and on the night immediately following an

Table 2
Sleep/wake behavior as a function of sleep location.*

Characteristic	Sleep location		
	Adelaide, Australia (mean ± SD)	Flight (mean ± SD)	Hiroshima, Japan (Mean ± SD)
Bedtime (hh:mm)*	23:40 ± 01:11[a]	03:55 ± 00:22[a,b]	00:27 ± 01:04[b]
Get-up time (hh:mm)	08:17 ± 01:18	08:34 ± 00:50	09:18 ± 02:01
Sleep latency (min)	8.5 ± 11.1	5.8 ± 9.4	19.8 ± 24.5
Time in bed (h)*	8.3 ± 1.7	4.4 ± 0.7	8.5 ± 2.3
Total sleep time (h)*	7.0 ± 1.6	3.4 ± 0.5	7.0 ± 2.1
Sleep efficiency (%)	87.5 ± 4.0	88.2 ± 7.8	87.6 ± 5.3
Movement and fragmentation index (units)	32.1 ± 9.5	33.3 ± 11.9	30.6 ± 8.4
Presleep fatigue (units)	4.9 ± 0.9	5.4 ± 1.3	4.8 ± 1.4
Postsleep fatigue (units)	3.0 ± 1.3	4.0 ± 1.4	3.6 ± 1.2
Subjective sleep quality (units)	2.0 ± 0.9	2.8 ± 1.3	2.1 ± 1.0

Note: Times for sleep during flights are reported in city departure time. * Significant main effect. Mean values with the same superscript are significantly different ($P < .05$).

evening game. On the night immediately after the evening game, the players initiated sleep 2.5 hours later and obtained 2.1 hours less sleep when compared to sleep immediately following the day game. In the present study, following night matches, soccer players initiated sleep much later (+2.2 hours), spent less time in bed (−2.9 hours), and obtained less sleep (−2.5 hours) when compared to a usual training day. Interestingly, soccer players obtained the most amount of sleep the night immediately prior to competition compared to any other day including rest days. This is contrary to many studies indicating that athletes sleep poorly the night immediately prior to competition.[21,24,25] Although these studies are limited to retrospective techniques, 2 recent studies using wrist actigraphy to monitor the sleep/wake behavior of Australian football and netball players revealed that they obtained more sleep the night before competition or rest days than immediately after a game.[25] This was a result of both Australian football and netball games typically played in the late afternoon and evening, allowing football and netball players to extend their sleep the morning of competition. Further, Juliff et al[26] found that sleep efficiency before rest days were higher compared to sleep after a game in their sample of netball players. Data from the present study showed similar findings; however, statistical significance was not reached, most likely because of the limitations in the sample size.

The main cause for longer sleep durations the night immediately prior to competition compared to training days was the timing of the 2 competition games. The first group stage match held in Adelaide, Australia, commenced at 19:00, and the return match in Hiroshima, Japan, commenced at 19:30. This enabled players to wake up considerably later on the morning of both days of competition. On average, players woke up over an hour later the morning of competition (ie, 09:21) and rest days (ie, 09:19) compared to training days (ie, 08:13). This finding is relatively consistent with previous data suggesting that training and competition schedules dictate the sleep/wake behavior of elite athletes.[16,17,27] For example, Sargent et al (2014) demonstrated that athletes woke up over an hour later on rest days compared to training days. Although the findings of this study indicate that athletes slept longer the night prior to competition, it is important to consider the impact of training and competition schedules on the sleep/wake behaviors of elite athletes.

Impact of flight on soccer players' sleep

The present study examined the effect of long-haul air travel, with minimal change in time zone, on the sleep of professional soccer players during the Asian Champions League. The timing of the flight to Japan significantly disrupted the sleep/wake behavior of soccer players. During flights, players initiated sleep much later (+3.5 hours), obtained less sleep (−3.6 hours), and reported poorer sleep quality compared to sleep in either their home location (Adelaide, Australia) or their away location (Hiroshima, Japan). To compensate for this loss of sleep, players extended their sleep the night immediately following arrival to 7.6 hours on the first night after arriving in Hiroshima and 9.5 hours on the first night after returning to Adelaide (Fig. 2). This considerable increase in total sleep time following the arrival back to Adelaide was due to the early flight schedule immediately after the away game (eg, day 16, Fig. 2). Surprisingly, only 2 players reported napping following arrival in Hiroshima (mean duration of nap = 1.2 hours). Although there were minimal time zone shifts, it is evident that boarding multiple flights and traveling a total of 20,422 km within a 6-day period with the addition of 2 competitive matches had significant effects on players' sleep. Therefore, it is plausible that sleep deficits evident within the present study are likely to be a result of congested schedules (eg, postmatch arousal, delayed sleep opportunity) instead of a by-product of transmeridian travel.

Studies have identified physiological consequences of air travel such as reduced oxygen saturation and sleep quality.[28] Conditions during air travel, particularly exposure to mild hypoxia, cramped conditions, long layovers, and restricted movement, can induce increases in perceptual fatigue and discomfort.[2,28] Although the present study identified adverse effects of travel and competitive matches on the sleep of soccer players, physical load or performance was not examined. Fowler et al (2015) revealed no relationship between sleep and performance during home and away matches during an A-League season. However, these matches were played within Australia, and the total distance traveled was considerably less (2453-5065 km) than the present study. Given the demanding nature of international travel and soccer matches as well as the recent emphasis of sleep, further research is necessary to examine the relationship between sleep, recovery via the evaluation of biochemical variables such as creatine kinase and interleukin, and performance during international competition.

Conclusion

Professional soccer teams are often required to travel and compete in multiple matches within a short period of time. This presents 2 main challenges for professional soccer players and staff. The first challenge is associated with overcoming the negative effects of long-haul travel, layovers, and travel fatigue, whereas the second challenge involves recovering from the physical demands of competitive soccer matches. These factors resulted in significant disruptions to sleep/wake behavior in the present group of professional soccer players. However, the findings from the present study indicate that, if given the opportunity, professional soccer players will compensate by extending their sleep the following day by 1 to 2 hours to ameliorate any sleep loss and fatigue.

Disclosure

The authors report no declarations of interest. The authors alone are responsible for the content and writing of this article.

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