The sleep behaviors of elite Australian Rules footballers before and after games during an entire season

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The Sleep Behaviors of Elite Australian Rules Footballers Before and After Games During an Entire Season

Charli Sargent, Brent Rogalski, Ashley Montero, and Gregory D. Roach

Purpose: Most athletes sleep poorly around competition. The aim of this study was to examine sleep before/after games during an entire season in elite Australian Rules footballers (N = 37) from the same team. ***Methods:*** Sleep was monitored using activity monitors for 4 consecutive nights (beginning 2 nights before games) during 19 rounds of a season. Differences in sleep on the nights before/after games, and differences in sleep before/after games as a function of game time (day vs evening), location (local vs interstate), and outcome (win vs loss), were examined using linear mixed effects models. ***Results:*** Players fell asleep earlier (+1.9 h; $P < .001$), and woke up later (+1 h; $P < .001$) on the night before games compared with the night of games. Players obtained less sleep on the night of games than on the night before games (5.2 h vs 7.7 h; $P < .001$), and this reduction was exacerbated when games were played in the evening—after evening games, players obtained approximately 40 minutes less sleep than after day games ($P < .001$). Sleep duration on the nights before and after games was not affected by game location or game outcome, but players had later sleep onset ($P < .001$) and offset times ($P < .001$) on most nights when sleeping away from home. ***Conclusions:*** Elite footballers obtain good sleep on the night before games but obtain approximately 30% less sleep on the night of games. Given the role of sleep in recovery, it will be important to determine whether a reduction in sleep duration of this magnitude impairs recovery on the days following games.

Keywords*:* total sleep time, activity monitors, game outcome, travel, sleep timing, professional athletes

One of the many challenges for elite athletes is obtaining sufficient sleep. More than 70% of athletes fall short of their required sleep need on a regular basis by an hour or more,[1] and most athletes report sleeping worse than usual around competition.[2] This is an important issue given that sleep is an essential component in the preparation for, and recovery from, high performance sport.[3]

Most team-sport athletes are frequently exposed to competition. For example, in a regular home and away season, elite Australian Rules footballers compete almost every week for 23 rounds over a 6-month period. In addition, teams can travel interstate for 1 to 3 days to compete, and with games scheduled at different times during the day (approximately 13:00–15:00 h) and evening (approximately 16:00–20:00 h). Competing in the evening and sleeping in an environment away from home can impair the amount and quality of sleep obtained by elite athletes.[4–9]

The impact of competition on sleep has previously been examined in elite Australian Rules football players during selected rounds of a season. Players typically obtain good sleep the night before a game whether sleeping at home[5,10–12] or interstate,[5,11,12] but fall asleep later on the night of the game[5,10] and obtain less sleep than usual.[5,10,11] Furthermore, sleep duration on the night of an interstate evening game is reduced (approximately 2 h less) compared with a day game at home,[5] but there is no difference in sleep duration between the night of a day game and the night of an evening game when the games are played at home.[9] Taken together, the results indicate that sleep is not only affected by competition, but also is affected by the timing and location of games. In addition, there is some evidence to suggest that poorer self-perceived sleep before competition decreases the odds of winning.[13] However, sleep behavior on the nights before and after wins and losses has not been systematically evaluated in elite Australian Rules football players.[5,10–12]

One of the limitations of the aforementioned studies is the short observation period during which sleep is monitored. Typically, sleep is only assessed for 2 to 5 rounds during a season.[5,10–12] In some cases, the observation period does not include rounds played interstate[9] or rounds with evening games,[11,12] and sleep on nights after games is excluded from analyses.[12] However, if players are monitored over an entire season, this would provide a sufficient number of nights over which to evaluate the impact of game-related factors on sleep (eg, game time, game location, game outcome). Therefore, the aims of the present study were to determine (1) the timing, duration, quality, and likelihood of sleep (ie, sleep probability) in elite footballers on the nights before and after games during an entire season; (2) whether playing during the day or evening, or in local or interstate games, affects the timing, duration, quality, or probability of sleep obtained by elite footballers during an entire season; and (3) whether the timing, duration, quality or probability of sleep obtained by elite footballers differs on the nights before and after wins and losses. It was hypothesized that players will (1) have good sleep on the nights before games, but poorer sleep on the nights of games; (2) obtain less sleep after evening games compared with day games; (3) sleep better in the home environment compared with sleeping away; and (4) sleep better on the night prior to wins than on the night prior to losses, but will sleep poorer on the night of losses than on the night of wins.

Methods

Participants

The sample consisted of regular senior male Australian Rules footballers (N = 37) from the same club who competed in games

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during rounds 1 to 23 of a single season in the Australian Football League. The average age of the players was 24.8 (3.4) years, and average playing experience was 81 (70) games. Informed, written consent was provided by all players, and the study was approved by the Human Research Ethics Committee of the University of Western Australia.

Procedures

Sleep/wake behavior was monitored during an entire home and away season using wrist activity monitors. The monitors were worn for 4 consecutive nights of each round (ie, beginning 2 nights prior to games) by players who were selected in the team for that round and competed in the game. Each player wore the activity monitor on the same wrist and only removed the monitor when training or competing in games. For the purpose of the analyses reported in the present study, only nighttime sleep periods were considered. Ideally, sleep during naps would also be captured. However, to reduce the burden of data collection throughout the season, players were not required to record daytime naps. The players were free to consume training supplements, caffeine, and alcohol during the data collection period. Information regarding medication use (including sleeping pills) was not made available for analysis in this study. Players traveled east 2 days in advance for interstate games and experienced time zone changes of 1.5 to 2 hours.

Sleep

The activity monitors used in this study (Readiband; Fatigue Science Inc) were configured to sum and store data in 1-minute epochs based on activity counts. Raw activity counts were extracted from each device and scored using a proprietary algorithm (Philips Respironics).[14] Validation studies comparing wrist activity monitors with polysomnography report high levels of agreement in healthy adults (88%)[15] and well-trained athletes (81%–90%).[16] For each athlete, the following variables were derived for each sleep period: sleep onset time, sleep offset time, total sleep time, and sleep efficiency (Table 1).

Statistical Analyses

The aims of the study were addressed by conducting a series of linear mixed effects models using the variance components covariance structure and restricted maximum likelihood estimation. Differences in sleep variables on the nights before and after games were examined by entering "night relative to game" (night −2, night −1, night 0, and night +1) as a fixed effect into the model and participant as a random effect. Separate linear mixed effects models for each night relative to games (night −2, night −1, night 0, and night +1) were used to examine the impact of game time (day vs evening), game location (local vs interstate), and game outcome (win vs loss) on the dependent sleep variables. In each respective model, participant was entered as a random effect, and then either "game time," "game location," or "game outcome" was entered as a fixed effect. Where appropriate, main effects were examined using pairwise comparisons. Statistical analyses were performed using SPSS (version 27; IBM). Results are reported as mean (SD) and were considered significant at $P < .05$. Sleep probability curves were constructed for each night of sleep (night −2, night −1, night 0, and night +1) and plotted as a function of game location (local vs interstate), game time (day vs night), and game outcome (win vs loss). The sleep probability curves represent the percentage of players that were asleep at each time of day (in 1-min epochs) based on data from the wrist activity monitors.

Results

Compliance

In total, 1229 nights of data were collected during the season (Table 2). Data were not collected in rounds 1, 17, and 23 due to time constraints and practical issues and were not collected during round 12 (bye). For most rounds, data were collected on night −2, night −1, night 0, and night +1, but there were some rounds with missing data on night 0 and night +1. The final data set included nights of sleep from 19 out of 23 rounds; 9 local games and 10 interstate games; 9 daytime games and 10 evening games; and 9 wins and 10 losses (Table 2).

Sleep Variables Averaged Across the Season

Throughout the season, average sleep onset was 00:06 (01:42) hour, and average sleep offset was 07:42 (01:24) hour. The players obtained an average of 6.8 (1.9) hours of sleep with an average sleep efficiency of 77.1% (13.8%).

Sleep Variables on the Nights Before and After Games

Sleep probability as a function of nights before and after games is presented in Figure 1. The column contains 4 panels—one panel for each night relative to the game (night −2, night −1, night 0, and night +1). In general, sleep was best on the night immediately prior to games and was poorest on the night of games (Figure 2; Table 3).

There was an effect of night relative to game on sleep onset ($F_{3,1276} = 110.5$, $P < .001$). The players fell asleep later on night 0 compared with night −2 (+1.6 h; $P < .001$), night −1 (+1.9 h; $P < .001$), and night +1 (+1.8 h; $P < .001$).

There was an effect of night relative to game on sleep offset ($F_{3,1276} = 46.5$, $P < .001$). The players woke up later the morning after night −2 compared with the morning after night −1 (+18 min; $P = .022$), the morning after night 0 (+60 min; $P < .001$), and the morning after night +1 (+60 min; $P < .001$). The players also woke up later the morning after night −1 compared with the morning after

Table 1 Sleep Variables

Variable	Definition
Sleep onset, h:min	The time at which a player first fell asleep after going to bed.
Sleep offset, h:min	The time at which a player last woke before getting up.
Sleep period, h	The amount of time between sleep onset and sleep offset.
Total sleep time, h	The amount of sleep obtained during a sleep period (ie, between sleep onset and sleep offset).
Sleep efficiency, %	Sleep duration expressed as a percentage of the sleep period (ie, total sleep time divided by sleep period multiplied by 100).

Table 2 Number of Nights of Sleep Collected During Each Round of the Season and Characteristics of the Round

Round	Night −2	Night −1	Night 0	Night +1	Location of game	Time of game	Outcome of game
1	NA	NA	NA	NA	Interstate	4:40 PM[E]	Loss
2	21	21	21	21	Local	2:40 PM[D]	Loss
3	21	21	21	21	Interstate[A]	2:10 PM[D]	Win
4	18	19	19	18	Local	5:40 PM[E]	Loss
5	19	20	20	20	Interstate	7:15 PM[E]	Loss
6	18	21	20	0	Local	2:40 PM[D]	Win
7	21	21	21	20	Interstate[A]	2:10 PM[D]	Win
8	11	20	18	14	Local	6:40 PM[E]	Win
9	19	19	20	20	Interstate[A]	2:10 PM[D]	Win
10	19	18	18	17	Local	5:40 PM[E]	Loss
11	19	18	18	14	Interstate[A]	4:40 PM[E]	Win
12	Bye	Bye	Bye	Bye	Bye	Bye	Bye
13	17	19	17	18	Interstate	7:50 PM[E]	Loss
14	14	12	13	13	Local	6:10 PM[E]	Loss
15	19	19	14	15	Interstate	7:10 PM[E]	Win
16	18	19	17	17	Local	2:40 PM[D]	Loss
17	NA	NA	NA	NA	Local	2:40 PM[D]	Loss
18	17	16	14	15	Interstate[A]	3:15 PM[D]	Loss
19	18	17	NA	NA	Local	2:40 PM[D]	Win
20	18	17	NA	NA	Interstate[A]	1:10 PM[D]	Win
21	18	17	NA	NA	Local	5:40 PM[E]	Loss
22	20	19	17	NA	Interstate	7:50 PM[E]	Loss
23	NA	NA	NA	NA	Local	6:10 PM[E]	Loss
Total	345	353	288	243			

Abbreviation: NA, not available. Note: Data are presented as counts. Night −2 = the sleep that occurred 2 nights prior to a game; Night −1 = the sleep that occurred the night before a game; Night 0 = the sleep that occurred the night of the game; Night +1 = the sleep that occurred the night after the game. Data were not collected due rounds 1, 17, and 23 due to practical/time constraints and were not collected during round 12 (bye).
[A]Return travel home from interstate on the same day as the game. [D]Day game. [E]Evening game.

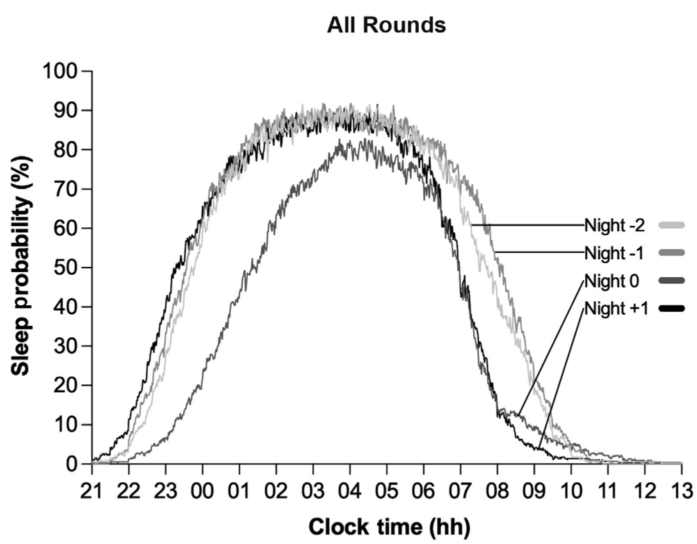

Figure 1 — Sleep probability for nights relative to games—2 nights before games, the night before games, the night of games, and the night after games.

night 0 (+42 min; $P < .001$) and the morning after night +1 (+42 min; $P < .001$).

There was an effect of night relative to game on total sleep time ($F_{3,1276} = 173.1$, $P < .001$). The players obtained less sleep on night 0 compared with night −2 (−2.1 h; $P < .001$), night −1 (−2.5 h; $P < .001$), and night +1 (−1.6 h; $P < .001$). The players also obtained more sleep on night −1 compared with the night −2 (+25 min; $P = .002$) and night 0 (+51 min; $P < .001$); and the players obtained more sleep on night −2 compared with night +1 (+26 min; $P = .003$).

There was an effect of night relative to game on sleep efficiency ($F_{3,1276} = 8.9$, $P < .001$). Sleep efficiency was lower on night 0 compared with night −2 (−3.8%; $P = .003$), night −1 (−3.9%; $P = .001$), and night +1 (−5.5%; $P < .001$).

Sleep Variables as a Function of the Time of Day of Games

Sleep probability as a function of the time of day of games is presented in the left column of Figure 3. There was no difference in any of the sleep variables on the 1 to 2 nights before, and the night after, day games and evening games (Figure 3; Tables 3 and 4). However, on the night of evening games (ie, night 0), players fell asleep 1.4 hours later ($P < .001$), woke up 48 minutes later the next

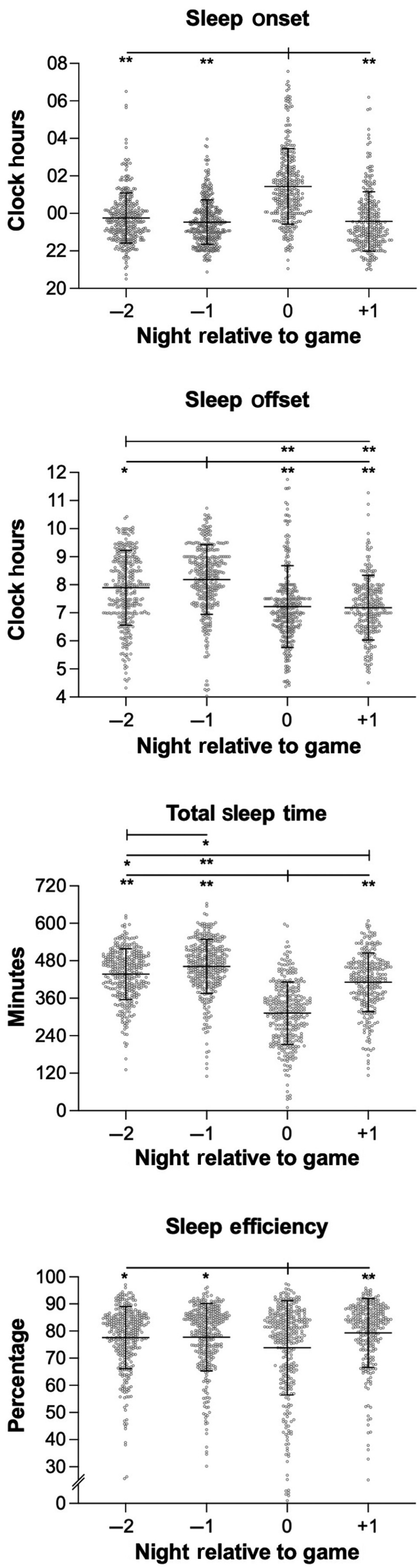

Figure 2 — Mean (SD) (lines and error bars) and individual cases (open circles) of sleep onset time, sleep offset time, total sleep time, and sleep efficiency plotted as a function of night relative to game.

morning ($P < .001$), and obtained 37 minutes less sleep ($P < .001$) than on the night of day games (ie, night 0).

Sleep Variables as a Function of Game Location

Sleep probability as a function of game location is presented in the left column of Figure 4. Overall, the players fell asleep later most nights, and woke up later most mornings, when games were played interstate than when games were played locally (Figure 4; Tables 3 and 4). During interstate rounds, the players fell asleep later on night −2 (+1.2 h), night −1 (+48 min), and night 0 (−1.7 h) compared with the corresponding nights during local rounds. Similarly, the players woke later on mornings after night −2 (+1.7 h), night −1 (+42 min), and night 0 (+42 min) during interstate rounds compared with the corresponding mornings during local rounds but woke approximately 24 minutes earlier on the morning after night +1 during local rounds compared with interstate rounds. The players obtained approximately 37 minutes more sleep on night −2 during interstate rounds compared with local rounds. However, the players obtained approximately 52 minutes less sleep on night 0 during interstate rounds compared with local rounds. There was no effect of game location on sleep efficiency for night −2, night −1, night 0, or night +1.

Sleep Variables as a Function of Game Outcome

Sleep probability as a function of game outcome is presented in the left column of Figure 5. In general, there was no difference in the duration or efficiency of sleep on the 1 to 2 nights before and after wins and losses (Figure 5; Tables 3 and 4). However, there were differences in the timing of sleep before and after wins and losses. Prior to wins, players fell asleep 18 minutes later ($P = .018$) on night −2 and fell asleep 18 minutes later ($P = .017$) on night −1, compared with night −2 and night −1 prior to losses. Prior to wins, the players also woke 24 minutes later the morning after night −1 compared with the morning after night −1 prior to losses ($P = .003$). On the night of losses (ie, night 0), players fell asleep 36 minutes later ($P = .009$) and woke 24 minutes later the next morning ($P = .020$) compared with the night of wins (ie, night 0).

Discussion

The primary findings of this study are that elite Australian Rules footballers (1) obtain good sleep (approximately 7.5 h) 1 to 2 nights before games, but obtain approximately 2.5 hours less sleep on the nights of games; (2) fall asleep approximately 1.4 hours later, and obtain approximately 40 minutes less sleep on the nights of evening games than on the nights of day games; (3) obtain a similar amount of sleep on nights away from home than on nights at home; and (4) obtain a similar amount of sleep the nights before and after wins than on the nights before and after losses.

It is not uncommon for athletes to report sleeping poorly on the night prior to competition. For example, 64% of athletes indicate they have slept worse than usual on the night(s) prior to an important competition or game at least once in the prior 12 months.[2] In the present study, the players' perceptions of sleep on the nights prior to games was not assessed. However, throughout the season, average total sleep time was highest on the night prior to games compared with nights after games, and was also within the recommended sleep duration target of 7 to 9 hours for healthy adults.[17] Higher values for total sleep time on nights prior to games, compared with nights after games, has been reported in similar

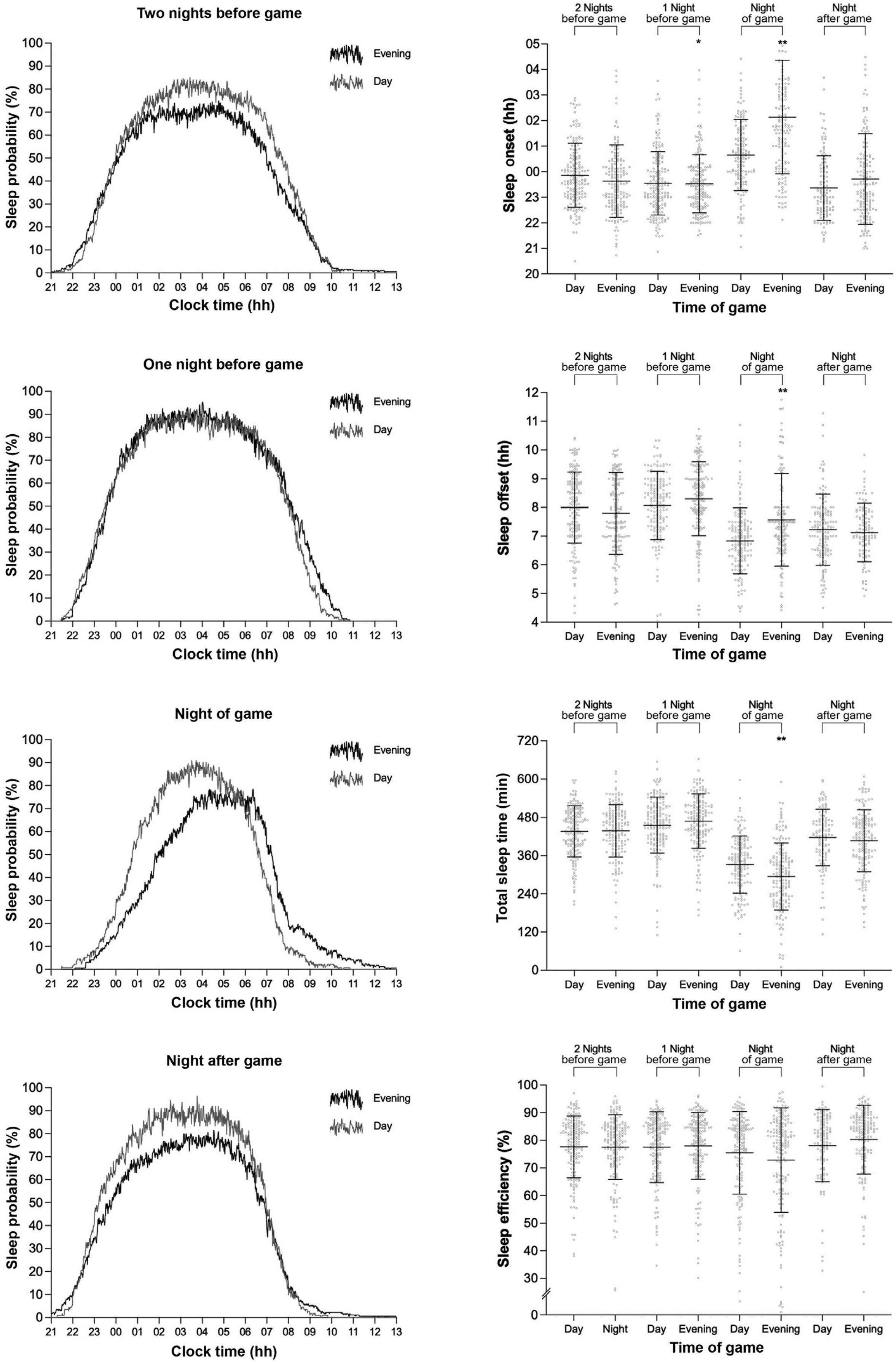

Figure 3 — Left panel: Sleep probability for day and evening games—2 nights before games, the night before games, the night of games, and the night after games. Right panel: Mean (SD) (lines and error bars) and individual cases (open circles) of sleep onset time, sleep offset time, total sleep time, and sleep efficiency for day games and evening games plotted as a function of night relative to game.

Table 3 Sleep Variables on the Nights Before and After Games Averaged Across All Rounds and Expressed as a Function of Game Time (Day and Evening), Game Location (Local and Interstate), and Game Outcome (Win and Loss)

Variable	Night −2	Night −1	Night 0	Night +1
All rounds				
Sleep onset, h:min	23:48 (01:18)	23:30 (01:12)	01:24 (02:00)	23:36 (01:36)
Sleep offset, h:min	07:54 (01:18)	08:12 (01:24)	07:12 (01:30)	07:12 (01:12)
Total sleep time, h	7.3 (1.4)	7.7 (1.4)	5.2 (1.7)	6.9 (1.6)
Sleep efficiency, %	77.6 (11.4)	77.7 (12.4)	73.8 (17.4)	79.3 (12.7)
Game time—day				
Sleep onset, h:min	23:52 (1:15)	23:33 (1:14)	00:39 (1:23)	23:22 (1:26)
Sleep offset, h:min	08:00 (1:14)	08:04 (1:11)	06:50 (1:09)	07:07 (1:01)
Total sleep time, h	7.3 (1.3)	7.6 (1.5)	5.5 (1.5)	6.9 (1.5)
Sleep efficiency, %	77.6 (11.2)	77.5 (11.4)	74.9 (15.4)	78.1 (13.1)
Game time—evening				
Sleep onset, h:min	23:39 (1:25)	23:32 (1:08)	02:08 (2:13)	23:43 (1:46)
Sleep offset, h:min	07:48 (1:26)	08:34 (1:17)	07:14 (1:37)	07:46 (1:15)
Total sleep time, h	7.3 (1.4)	7.8 (1.4)	4.9 (1.8)	6.8 (1.6)
Sleep efficiency, %	77.5 (11.7)	78.0 (12.1)	72.8 (18.9)	80.2 (12.4)
Game location—local				
Sleep onset, h:min	23:09 (1:03)	23:05 (1:00)	00:30 (1:29)	23:45 (1:35)
Sleep offset, h:min	06:57 (0:49)	07:47 (1:10)	06:50 (1:06)	07:26 (1:06)
Total sleep time, h	6.9 (1.2)	7.7 (1.3)	5.7 (1.7)	6.9 (1.5)
Sleep efficiency, %	78.6 (10.6)	79.0 (11.1)	74.4 (17.1)	79.8 (10.9)
Game location—interstate				
Sleep onset, h:min	00:15 (1:21)	23:57 (1:11)	02:11 (2:05)	23:27 (1:35)
Sleep offset, h:min	08:40 (1:10)	08:32 (1:13)	07:32 (1:38)	07:00 (1:10)
Total sleep time, h	7.6 (1.4)	7.7 (1.6)	4.8 (1.5)	6.8 (1.6)
Sleep efficiency, %	76.8 (12.0)	76.6 (13.4)	73.3 (17.6)	79.0 (13.9)
Game outcome—win				
Sleep onset, h:min	23:56 (1:13)	23:41 (1:16)	01:07 (1:28)	23:38 (1:43)
Sleep offset, h:min	8:07 (1:12)	8:18 (1:07)	7:01 (1:04)	7:06 (1:15)
Total sleep time, h	7.3 (1.4)	7.7 (1.6)	5.3 (1.4)	6.7 (1.6)
Sleep efficiency, %	77.9 (11.1)	78.2 (13.4)	75.5 (14.7)	78.8 (14.1)
Game outcome—loss				
Sleep onset, h:min	23:35 (1:26)	23:23 (1:05)	01:43 (2:22)	23:32 (1:31)
Sleep offset, h:min	07:41 (1:26)	08:04 (1:21)	07:24 (1:43)	07:14 (1:06)
Total sleep time, h	7.2 (1.3)	7.7 (1.3)	5.1 (1.8)	7.0 (1.5)
Sleep efficiency, %	77.2 (11.8)	77.2 (11.4)	72.4 (19.3)	79.7 (11.8)

Note: Data are presented as mean (SD). Night −2 = the sleep that occurred 2 nights before a game; Night −1 = the sleep that occurred the night before a game; Night 0 = the sleep that occurred the night of the game; Night +1 = the sleep that occurred the night after the game.

cohorts of Australian Rules football players.[5,10–12] Good sleep on the night prior to games most likely reflects voluntary behavior—that is, players maintain or increase their total sleep time in an attempt to maximize their next-day game performance.[11] There is also evidence to suggest that athletes from team sports are less likely to report poor sleep prior to important competition or games compared with athletes from individual sports.[18] It is possible that athletes who perform as part of a team experience less pressure or stress compared with athletes who participate in individual sports, because they are not solely responsible for the team's performance.[18] Weekly exposure to competition, as occurs in the Australian Football League, would also provide players with regular opportunities to develop good sleep routines prior to games.[18]

The results of the present study indicate that elite Australian Rules footballers are most susceptible to sleep loss on the nights of games. Compared with sleep duration 1 to 2 nights prior to games (approximately 7.5 h), players obtain an average of only 5.2 hours of sleep on the night of games. This represents a 30% reduction in sleep duration and is well below the 8.4 hours of sleep Australian Rules Footballers report needing to feel fully rested.[1] Sleep on the night of games was also characterized by a later sleep onset time

Table 4 Results of Linear Mixed Effects Models Examining the Impact of Game Time (Day vs Evening), Game Location (Local vs Interstate), and Game Outcome (Win vs Loss) on Sleep

	Sleep onset			Sleep offset			Total sleep time			Sleep efficiency		
Comparison	***F***	**df**	***P***	***F***	**df**	***P***	***F***	**df**	***P***	***F***	**df**	***P***
Day vs evening												
Night −2	2.5	1, 336	.118	1.9	1, 336	.167	0.0	1, 336	.870	0.0	1, 336	.924
Night −1	0.0	1, 347	.896	2.7	1, 347	.099	1.8	1, 347	.185	0.1	1, 347	.749
Night 0	50.1	1, 318	**<.001**	21.3	1, 318	**<.001**	11.7	1, 318	**<.001**	1.2	1,3 18	.280
Night +1	3.2	1, 270	.074	0.5	1, 270	.478	0.7	1, 270	.393	1.9	1, 270	.172
Local vs interstate												
Night −2	67.9	1, 366	**<.001**	235.3	1, 366	**<.001**	18.2	1, 366	**<.001**	2.0	1, 366	.159
Night −1	53.0	1, 348	**<.001**	35.1	1, 348	**<.001**	0.0	1, 348	.871	3.2	1, 348	.076
Night 0	66.1	1, 318	**<.001**	19.0	1, 318	**<.001**	23.1	1, 318	**<.001**	0.3	1, 318	.577
Night +1	2.4	1, 270	.124	10.1	1, 270	**.002**	0.3	1, 270	.615	0.3	1, 270	.586
Win vs loss												
Night −2	5.7	1, 336	**.018**	9.0	1, 336	**.003**	0.7	1, 336	.396	0.3	1, 336	.577
Night −1	5.6	1, 348	**.018**	3.1	1, 348	.081	0.0	1,348	.985	0.6	1, 348	.444
Night 0	6.9	1, 318	**.009**	5.4	1,318	**.020**	0.6	1, 318	.436	2.7	1, 318	.105
Night +1	0.3	1, 270	.570	1.0	1, 270	.309	2.0	1,270	.160	0.3	1, 270	.570

Note: Night −2 = the sleep that occurred 2 nights prior to a game; Night −1 = the sleep that occurred the night before a game; Night 0 = the sleep that occurred the night of the game; Night +1 = the sleep that occurred the night after the game.
P values less than .05 are indicated in bold.

compared with the night before games (01:26 h vs 23:32 h) and an earlier sleep offset time the following morning (07:13 h vs 08:11 h).

Athletes typically experience poor sleep on the night of games, but this tends to be exacerbated when games take place in the evening. For example, after a single game in the evening, team-sport athletes obtain almost 2 hours less sleep compared with the night of a day game or the night before a game.[4,5,8,9,19] In the present study, approximately 50% of the games were classified as evening games (start time between 16:40 and 19:50 h), resulting in approximately 150 nights of sleep for analysis after evening games. The players fell asleep much later on the night of evening games than on the night of day games (approximately 02:00 h vs approximately 00:40 h) and obtained approximately 40 minutes less sleep on the night of evening games. Interestingly, almost 60% of team-sport athletes report having no strategy to overcome poor sleep on such occasions.[2] The results of the present study indicate that strategies aimed specifically at mitigating sleep loss on the night of games—which have been implemented with some success with other athletes[20]—may be beneficial for elite Australian Rules footballers.

Sleeping in an environment away from home can also influence the quantity and quality of sleep obtained.[6] In the present study, the location of games primarily affected the timing of sleep. Sleep onset and sleep offset occurred 1 to 2 hours later on most nights away from home compared with nights at home. This delay is not unexpected given that the players in the present study experienced a time zone change of 1.5 to 2 hours when playing games interstate. The players' circadian timing systems cannot immediately adapt to a change in time zone, which means they would have difficulty falling asleep and waking up at their usual time.[21] It is possible to minimize the impact of the time zone change on sleep onset and offset times by using timed exposure to bright light prior to departure,[21] but given that sleep duration and efficiency were preserved during nights away compared with nights at home, such an approach may not be warranted. The location of games also had a minor influence on sleep duration. The players obtained approximately 37 minutes more sleep 2 nights prior to interstate games than prior to local games, but obtained approximately 50 minutes less sleep on the night of interstate games than on the night of local games. It is not clear from the present study why sleep duration may differ depending on game location. When away from home players may have fewer social/family commitments on the nights before games, which may allow them to prioritize sleep. Interstate games also require the players to move and travel in a group—less sleep on the nights of interstate games than on the nights of local games may simply reflect (1) the logistics of being in a group and having to wait until all players are ready to leave the game venue rather than players leaving of their own volition when playing locally and/or (2) the logistics of traveling home either immediately after interstate games, or early in the morning after interstate games, and the accompanying worry associated with travel.

The relationship between sleep quality and quantity and game outcome is most likely bidirectional—that is, how well players sleep prior to a game could influence the outcome of the game, and the outcome of a game could influence how well players sleep after a game. In the present study, sleep duration and sleep efficiency on the nights before and after wins and losses were similar. However, there were minor differences in the timing of sleep on the nights before, and the night of, wins and losses. On the nights prior to wins, players fell asleep approximately 20 minutes earlier than on the nights prior to losses. There is some evidence to suggest that poorer self-perceived sleep quality prior to competition in elite team-sport athletes reduces the odds of winning.[13] However, it seems unlikely that the small difference in sleep onset time on the nights prior to wins observed in the present study influenced the outcome of games. On the nights of losses, players fell asleep approximately 37 minutes later than on the nights of wins. Being successful or unsuccessful in competitive sport—through winning or losing—can result in different responses in players' mood and affect. For example, winning tends to result in a range of pleasant

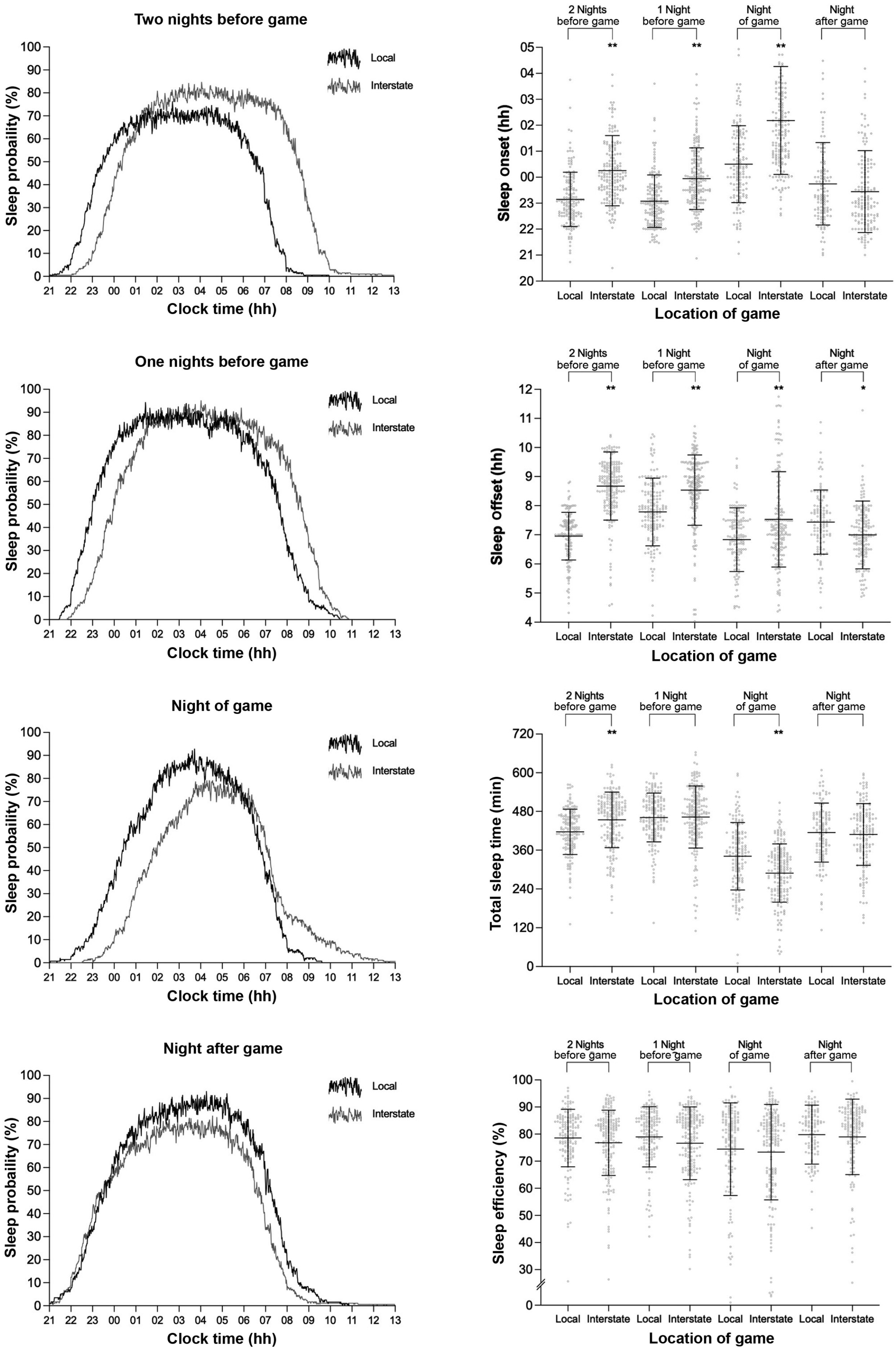

Figure 4 — Left panel: Sleep probability for local and interstate games—2 nights before games, the night before games, the night of games, and the night after. Right panel: Mean (SD) (lines and error bars) and individual cases (open circles) of sleep onset time, sleep offset time, total sleep time, and sleep efficiency for local and interstate games plotted as a function of night relative to game.

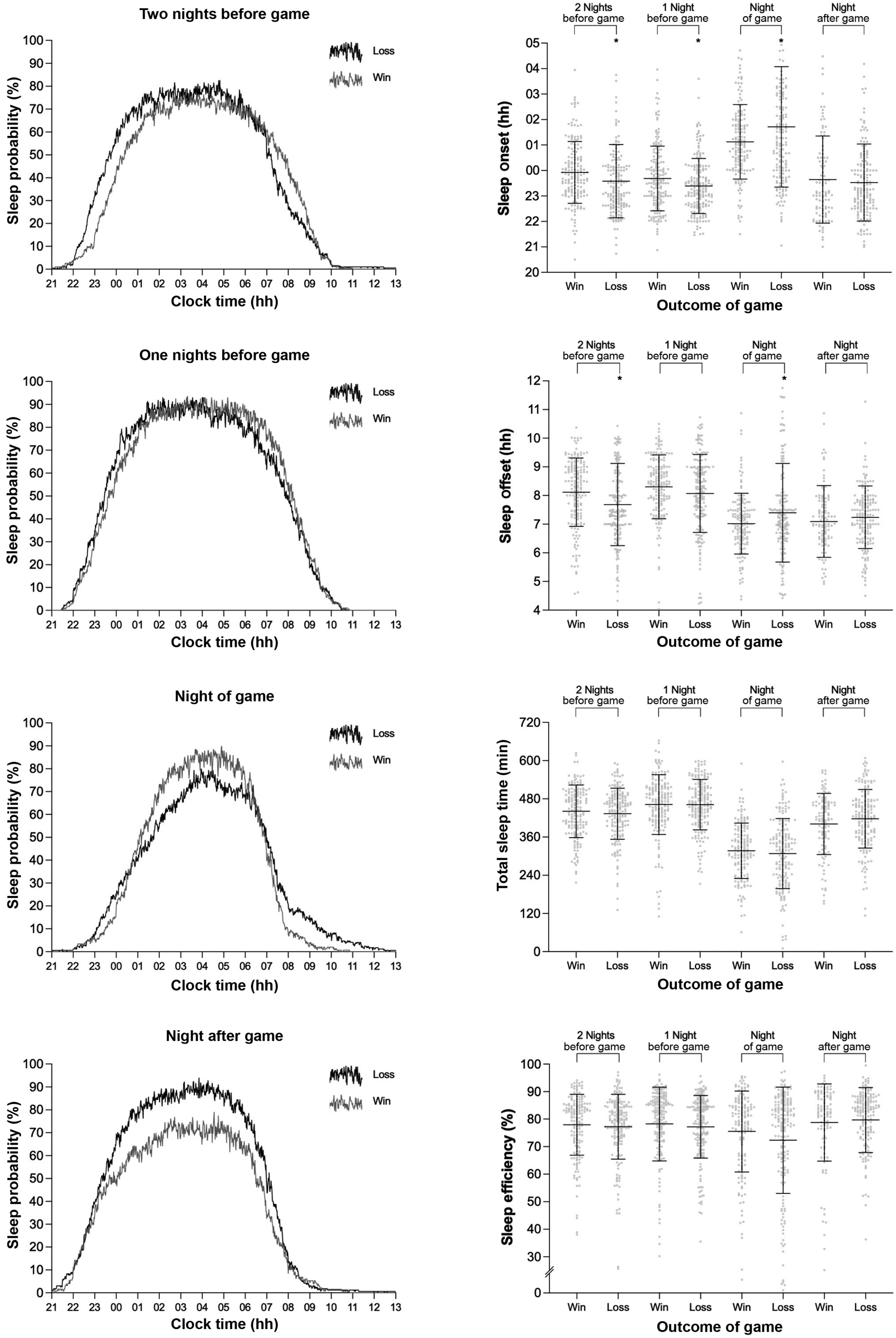

Figure 5 — Left panel: Sleep probability for wins and losses—2 nights before games, the night before games, the night of games, and the night after games. Right panel: Mean (SD) (lines and error bars) and individual cases (open circles) of sleep onset time, sleep offset time, total sleep time, and sleep efficiency for wins and losses plotted as a function of night relative to game.

emotional outcomes and reductions in arousal and stress. In contrast, losing results in strong unpleasant emotional changes, no reduction in stress, but a reduction arousal.[22] The difference in sleep onset time following wins and losses could be explained by differences in the emotional response to winning and losing—that is, pleasant emotional outcomes may result in earlier sleep onset times[23] and unpleasant emotional outcomes may result in later sleep onset times.[24]

It is not possible from the present study to determine why sleep duration is reduced on the night of games. It is likely that behaviors and commitments on the night of games (eg, caffeine consumption before/during games, team meetings, media responsibilities, injury management, return travel home etc)[7,25] prevent players from going to bed at their usual time and commitments in the morning following a game (eg, recovery, injury management, return travel, etc)[5] prevent players from waking up later to compensate for the delay in sleep onset experienced on the previous night. It may not always be practical to delay the start time of the first commitment on the morning after a game, but it would provide an option to mitigate some of the sleep loss that occurs on the night of games by providing players with a greater opportunity for sleep.

There are some limitations that should be considered when interpreting the results of the present study. Data were collected with the players during an entire season and while compliance was generally good on most nights, compliance was very poor on the nights after games in rounds 19 to 22. Nevertheless, the data set contains >1000 nights of sleep that were obtained during most rounds of the season. Recruiting players from the same team facilitated data collection, but travel requirements are not the same for all teams in the Australian Football League. The sleep/wake behavior for away games in the present study may not reflect the sleep/wake behaviors of players from other teams who travel in different directions.[21] It is also possible that players in the present study supplemented their nighttime sleep with daytime naps. Napping is an effective strategy when athletes' nighttime sleep is restricted[26] and some athletes do nap around competition.[27] Naps were not recorded in the present study, and this may result in an underestimate of total sleep time. Finally, activity monitors were used to assess sleep. These devices can either overestimate or underestimate sleep duration by 18 (52) and 54 (36) minutes, respectively,[15,16] The accuracy of the devices should be considered when interpreting the sleep variables reported in the present study.

Practical Applications

In the present study, sleep was poorest on the night of games—regardless of game location, game time, or game outcome. Compared with the night before games, players obtained approximately 30% less sleep on the night of games (7.7 h vs 5.2 h). Coaches, sports scientists, and support staff could use the information presented here to develop strategies to help players minimize sleep loss on the night of games by (1) facilitating earlier sleep onset times on the nights of games[21] and/or (2) promoting later sleep offset times in the mornings following games.

Conclusions

During an entire season, elite Australian Rules footballers obtain good sleep on the night prior to games (7.7 h) but are most susceptible to sleep loss on the night of games—regardless of whether games are played locally or interstate, during the day or the evening, or result in a win or a loss. Compared with the night before games, players fall asleep approximately 2.5 hours later and obtain approximately 30% less sleep on the night of games. Given the role of sleep in the recovery from exercise, it will be important to determine whether a reduction in sleep duration of this magnitude impairs recovery on the days following games.

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