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Association between late-night tweeting and next-day game performance among professional basketball players

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ABSTRACT

Objectives: In sports, decreased sleep duration is generally associated with poorer performance compared to adequate or enhanced sleep duration. Yet, these findings have primarily been taken from small numbers of athletes performing outside of real games or competitions. It remains unknown how acute decreased sleep duration impacts real-game performance among professional athletes. Here, we merged 2 publicly available datasets to jointly measure late-night social media activity (a proxy for sleep deprivation) and next-day game performance.
Setting: Professional basketball competition.
Participants: 112 players from the National Basketball Association.
Measurements: Time-stamped social media activity and in-game individual performance statistics.
Results: Late-night tweeting (compared to not late-night tweeting) is associated with within-person reductions in next-day game performance, including fewer points scored and fewer rebounds. However, we also observe less time played per game following late-night tweets and decreases in the negative outputs of turnovers and personal fouls. The critical measure of shooting accuracy – which is not time dependent – provides the clearest evidence of a performance penalty following late-night tweeting activity (between 11:00 PM and 7:00 AM); players successfully make shots at a rate 1.7 percentage points less following late-night tweeting.
Conclusions: Our findings suggest that acute sleep deprivation, as measured via late-night Twitter activity, is associated with changes in next-day game performance among professional National Basketball Association athletes. More broadly, the use of late-night social media activity may serve as a useful general proxy for sleep deprivation in other social, occupational, and physical performance-based contexts.

Introduction

The adverse effects of sleep deprivation on athletic performance are widely accepted, especially among sports requiring motor coordination, tactical decision making, and aerobic physical exertion.[1–4] However, there is less research assessing the real-world effects (eg, points scored, percentage of shots made) of sleep deprivation on professional athletes.[5,6] Given demanding training schedules, frequent travel, and the physical and psychological stresses of professional athletes, especially during the professional season,[7–10] sleep deprivation, which may hamper optimal game performance, has been reported by a majority of athletes.[11]

Previous studies have sought to characterize the relationship between sleep and sports performance using small cohorts of athletes in the laboratory and in the field. Studies that experimentally introduced sleep deprivation and examined next-day performance on tests of aerobic exercise have demonstrated significant performance decrements.[12–15] Observational studies correlating self-reported sleep quantity and quality among such athletes have likewise demonstrated a significant association with athletic performance.[16,17] Conversely, studies that have experimentally extended sleep duration have revealed positive effects on performance, especially in sports demanding high levels of technical skill and hand-eye coordination and particularly when sleep is extended in the weeks leading up to performance evaluation.[18–20] Despite these mostly consistent findings, the observational studies suffer from the possibility of selection bias (better or longer sleepers may happen to also be better athletes), and the

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outcomes measured are mostly isolated components of performance (eg, strength or speed) rather than game performance in the context of competitive play. Furthermore, many prior studies compare results across groups rather than looking at how a within-person difference in sleep duration might affect real-world performance. These limitations make it difficult to understand whether there are consequential effects of sleep deprivation on elite athletes.

In the present study, we implement a unique method to estimate the relationship between sleep duration and performance for professional athletes in high-stakes, real-world competition. We focus on professional basketball players and seek proxy measures for both late-night activity and next-day game performance. Briefly, we proxy late-night activity by examining the time-stamped tweets of National Basketball Association (NBA) players and contrast performance statistics when late-night activity was and was not observed. We hypothesized that players perform worse (eg, score fewer points) in games following late-night tweeting compared to their own performance in games following no late-night tweeting.

Methods

Our sample consists of NBA players who maintained an active verified Twitter account between 2009 and 2016. Twitter is a smartphone and Web application that allows users to publicly post short messages called *tweets*. It is a social media platform used by 24% of Americans and 45% of Americans aged 18–24.[21] For the purposes of the current study, its most important feature is the time stamp attached to each tweet. With the time stamp and time zone, we can infer the local time each tweet was sent by the user. Previous work has used this information to estimate mood per time of day[22] and the sleep schedule of President Trump.[23]

We sought measures of both in-game player performance and previous night sleep duration. Whereas individual player performance measures are easily accessible through numerous online sources, retrospective information on sleep duration for each player is much more difficult to obtain. As a proxy, we used time-stamped tweets to identify nights on which players were awake late at night and potentially did not get sufficient sleep. In general, activity on Twitter follows a circadian pattern (Supplementary Fig. 1) of higher activity during normal waking hours (7:00 AM through 11:00 PM) and lower activity during normal sleeping hours (11:00 PM through 7:00 AM).

We merged data from 2 publicly available sources to create our dataset. Regular-season game statistics for NBA players were collected from the Web sites of Yahoo Sports.[24] Twitter account activity for individual players was obtained using the Twitter REST API.[25] We first identified a list of NBA-related accounts compiled by Twitter and retrieved all 581,190 tweets from accounts on that list. Then, we filtered the dataset to 37,073 tweets from verified Twitter accounts of NBA players who played in the seasons between 2009 and 2016. To avoid the potentially confounding effects of prolonged travel/jetlag on tweeting behavior and performance, analysis was restricted to players from East Coast teams playing games on the East Coast and players from West Coast teams playing on the West Coast.

Late-night tweets were defined as those occurring between 11:00 PM on the night prior to game day and 7:00 AM on game day. We measured performance using the following variables: total points scored, shooting percentage, rebounds, turnovers, and fouls. The first 3 are desirable basketball outcomes—scoring more points, shooting more accurately, and obtaining more rebounds all help one's team. The latter 2 are undesirable—losing control of the ball to the other team and committing more fouls are helpful to the *opposing* team.

In addition to the primary analysis, we conducted further exploratory analyses. We performed sensitivity analyses with a narrower window of tweeting: tweets occurring between 2:00 AM and 6:00 AM. To examine contextual effects, we repeated the primary analyses stratified by home and away games. Finally, we classified players as frequent or infrequent late-night tweeters. To do so, we calculated the proportion of all games preceded by a late-night tweet for each player and split on the median value.

All analysis was conducted within subject. Each player's performance was contrasted between games *not* preceded by a late-night tweet (labeled *No-LNT*) and games that *did* follow a late-night tweet (*LNT*). Two-tailed, paired t tests were performed to test for reliable differences in performance between No-LNT and LNT games. We describe a test that rejects the null hypothesis of zero difference at an α level of .05 as statistically significant; P values for each test are reported in the tables.

Results

Table 1 summarizes the results. Comparing each player to himself for No-LNT and LNT performance, we find a general pattern. Following late-night tweeting, players contributed fewer points and rebounds. We estimate that players score 1.14 fewer points (95% confidence interval [CI]: 0.56-1.73) following a late-night tweet. Similarly, we estimate that players secure 0.49 fewer rebound (CI: 0.25-0.74). They also commit fewer turnovers and fouls in games following a late-night tweet. We estimate the differences to be 0.15 fewer turnover (CI: 0.06-0.025) and 0.22 fewer foul (CI: 0.12-0.33). These results are consistent with a hypothesis that players are less active in a game following a late-night tweet but not that the general quality of their play necessarily deteriorates.

We noted that, on average, players spent 2 fewer minutes on the court following late-night tweeting (no late-night tweeting: 24.8 minutes, late-night tweeting: 22.8 minutes). We therefore examined the association between late-night tweeting and game statistics on a per-minute basis (Supplementary Table 1). In this analysis, the difference in turnovers and fouls between LNT and No-LNT disappears, whereas the effects for points scored and rebounds were reduced and not significant at the .05 level. We did not normalize shooting percentage by minutes played given that shooting percentage is dependent on number of shots attempted rather than on minutes played.

For additional analysis, we stratified our results by whether games were played at home or away. One might imagine that the difference in performance following a late-night tweet would be more pronounced in one setting or the other. Table 2 presents the results for home and away games. The notable differences are in shooting percentage and turnovers. The point estimates for the shooting percentage suggest perhaps that the late-night tweeting penalty is larger for away games at −3.95% when compared to home games at −0.76%. However, the CIs overlap to the extent that we would not interpret this difference-in-differences as significant: away CI: −1.21% to −6.70%, home CI: +1.10% to −2.62%. Similarly, the pattern for turnovers indicates nominally more turnovers following late-night tweets in home games as compared to away games, but we do not interpret the difference-in-difference as significant.

Table 1
Performance not following a late-night tweet (No-LNT) compared to following a late-night tweet (LNT)

Variable	No-LNT performance	LNT performance	Difference	t	P
Total points scored	10.56	9.42	1.14	3.86	.0002
Shooting percentage	45.35	43.65	1.70	2.11	.0376
Rebounds	4.50	4.01	0.49	3.96	.0001
Turnovers	1.47	1.31	0.15	3.33	.0012
Fouls	2.06	1.84	0.22	4.12	.0001

N = 112 players.

Table 2
Performance No-LNT compared to LNT for home and away games

Variable	No-LNT performance	LNT performance	Difference	*t*	*P* value
Home					
Total points scored	10.74	9.77	0.97	3.15	.0021
Shooting percentage	45.53	44.77	0.76	0.81	.4181
Rebounds	4.56	4.04	0.52	3.65	.0004
Turnovers	1.48	1.30	0.18	3.44	.0008
Fouls	2.04	1.85	0.19	3.56	.0005
Away					
Total points scored	10.65	9.25	1.40	3.59	.0005
Shooting percentage	44.87	40.92	3.95	2.86	.0052
Rebounds	4.55	4.18	0.37	2.51	.0137
Turnovers	1.48	1.41	0.07	1.03	.3050
Fouls	2.12	1.93	0.19	2.61	.0104

N = 112 players.

We next narrowed our definition of late-night tweeting to include only those nights in which tweets were posted between 2:00 AM and 6:00 AM. This tighter window provides the advantage of more stringently restricting observations to typical sleeping hours. However, it also reduces the amount of data available because less late-night tweeting activity is observed in this period. Indeed, only 51 players provide usable data with this definition of late-night activity as compared to 112 players when using the 11:00 PM to 7:00 AM window. As shown in Table 3, even after reducing the dataset by more than half, all the observed differences remain significant with the exception of shooting percentage.

Finally, we examined frequent and infrequent late-night tweeters separately. Players who make a habit of "late-night tweeting" may be chronically sleep deprived or may instead be on a nonstandard sleep schedule. Contrasting frequent and infrequent late-night tweeters may yield insight into which group is more affected by pregame late nights. We found that infrequent late-night tweeters who late-night tweeted before a game scored significantly fewer points; made a lower percentage of shots; and also contributed fewer rebounds, turnovers, and fouls as compared to nights when they did not late-night tweet. By contrast, these effects were not seen among frequent late-night tweeters (Table 4).

Discussion

Sleep is often deemed to be essential for optimal athletic performance.[1,3] Yet, limited data exist addressing the question of whether staying up late the night before a real professional sporting event affects individual player performance. In this study, we tracked Twitter activity of professional NBA players the night before they participated in actual in-season games. We used late-night tweeting as a rough and indirect measure of sleep restriction and/or delayed sleep timing. Strikingly, we observed that, when compared to their own performance, players who late-night tweeted the night before a game exhibited significantly worse performance among favorable indices, including number of points scored, shooting percentage, and rebounds. However, we also noted that, in these games, players committed fewer fouls, were responsible for fewer turnovers, and played for fewer minutes. Importantly though, we found that shooting percentage, a time-independent measure, was significantly lower following late-night tweeting.

Table 3
Performance No-LNT compared to LNT with a narrower late-night window

Variable	No-LNT performance	LNT performance	Difference	*t*	*P*
Total points scored	10.87	9.53	1.34	2.37	.0214
Shooting percentage	46.21	45.34	0.87	0.60	.5494
Rebounds	4.65	3.95	0.70	2.86	.0062
Turnovers	1.56	1.34	0.22	2.65	.0106
Fouls	2.14	1.82	0.32	4.22	.0001

N = 51 players.

Table 4
Performance No-LNT compared to LNT for frequent and infrequent late-night tweeters

Variable	No-LNT performance	LNT performance	Difference	*t*	*P*
Frequent					
Total points scored	10.16	9.95	0.21	0.77	.4463
Shooting percentage	45.38	45.59	−0.21	0.29	.7747
Rebounds	4.51	4.38	0.13	1.03	.3070
Turnovers	1.47	1.47	0	0.01	.9936
Fouls	2.07	1.97	0.10	1.98	.0529
Infrequent					
Total points scored	10.97	8.89	2.08	4.18	.0001
Shooting percentage	45.32	41.64	3.68	2.56	.0132
Rebounds	4.50	3.64	0.86	4.15	.0001
Turnovers	1.47	1.16	0.31	4.04	.0002
Fouls	2.05	1.70	0.35	3.70	.0005

N = 112 players, median split on proportion of games following late-night tweets to create 56 frequent LNTers and 56 infrequent LNTers.

When we applied a more stringent definition of late-night tweeting (between 2:00 AM and 6:00 AM), our results were virtually identical to the wider interval of 11:00 PM and 7:00 AM. We also observed inconclusive but suggestive evidence that the effect of late-night tweeting on shooting percentage was larger for away games as compared to home games. Finally, we found that infrequent late-night tweeters were largely responsible for the significant associations we observed.

One important issue not addressed in these analyses is the team nature of the sport of basketball. As a reviewer pointed out, one can imagine an intrateam effect just as strong as an individual performance effect. For example, player A's ability to score might be negatively affected by player B's lack of sleep, leading to B missing an assist opportunity. Intrateam effects and aggregated measures of "team sleep" are intriguing possibilities for further research.

We acknowledge that our results are correlative in nature. Although we investigate within-person differences in performance, we are unable to account for external confounding factors (eg, personal stress) that may both increase late-night tweeting and decrease basketball performance. Furthermore, late-night tweeting is only a proxy for sleep deprivation and/or delayed sleep timing. Although it signals that a player is awake at a certain time, it cannot capture total sleep duration, sleep timing, and sleep quality. Nor does the lack of a late-night tweet indicate that the person is sleeping. Despite these limitations, it is simply the case that a randomized, controlled experiment will likely never be conducted involving disrupting the sleep of NBA players before a game. Previous experimental studies in professional athletes have mostly studied the effects of sleep extension, rather than restriction, on performance.[20,26,27] This leaves the question of whether sleep deprivation (which is likely more prevalent than sleep excess in these athletes) is important for performance. We sought to begin to address this question in the present study.

On the other hand, many questions we raised remain unresolved. One unknown is the reason why players spend less time on the court following late-night tweeting. Although we observed a significant decrease in number of minutes played, this ~2-minute difference in play time was smaller than what might be expected if, for instance, a player was a starter vs a bench player. Examination of histograms revealed a slight shift in the distribution, not a cluster of outlier values that might be explanatory. It is possible that coaches may recognize early and subtle indicators of poor performance among those who have stayed up late the night before a game and pull these players off the court sooner than they otherwise would have if the players had gotten a full night's sleep.

In total, the present findings support the idea that late-night tweeting may be a reasonable proxy for insufficient sleep or delayed sleep timing, at least among professional basketball players. These findings may extend into other arenas, such as job or academic performance and productivity. If generalizable, the free and publicly available massive dataset of Twitter activity could be used to address any number of psychological, sociological, health-related, or epidemiological questions. Here, we used these data as a proof of concept to demonstrate the novel, though perhaps unsurprising, finding that late-night tweeting was associated with reduced activity among professional NBA players in actual games.

Sleep deprivation is a prevalent problem in modern society. Approximately 30% of the general population gets significantly less sleep than the 7 hours that is recommended by the consensus statements of the National Sleep Foundation and the American Academy of Sleep Medicine.[28–30] Although the current study does not directly address the question of whether screen time affects sleep duration or sleep timing, a recent meta-analysis shows that mobile device use at bedtime is associated with inadequate sleep duration, poor sleep quality, and excessive daytime sleepiness among youth.[31] Future research should thus seek to determine whether late-night tweeting and other social media use in the general population, or particularly in vulnerable populations such as teenagers or shift workers, can predict various adverse health, performance, or safety outcomes. In addition, the content of such tweets may yield additional insights if systematically extracted and analyzed.

In summary, we have demonstrated a negative association between late-night tweeting and player outputs among professional athletes in the high-stakes, competitive environment of official NBA games. These findings may apply widely to other sports and other cognitive and behavioral outcomes. Twitter data may provide sleep and sports researchers with a new tool to examine the effects of late-night activity on a variety of outcome measures.

Disclosure

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Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.sleh.2018.09.005.

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