Sleep, 20(5):366–369

Effect of Travel and Rest on Performance of Professional Basketball Players

*Kyle Steenland and †James A. Deddens

**National Institute for Occupational Safety and Health, Centers for Disease Control, and †Department of Mathematics, University of Cincinnati, Cincinnati, Ohio, U.S.A.*

Summary: We have studied 8,495 regular season games in the National Basketball Association over eight seasons (1987–1988 through 1994–1995) to analyze the effects of travel and rest on performance. We found that more time between games improved performance, an effect that was constant over time and statistically significant. More than 1 day between games increased the home team's score by 1.1 points and the visitor's by 1.6 points. Peak performance occurred with 3 days between games. The negative effects of little time between games may be due to lack of time for physical recovery, rather than any effects of circadian rhythm (jet lag). We found few consistent effects of distance traveled or direction of travel. We did find a suggestion of circadian rhythm effects in a subanalysis of games on either coast in which the visitor traveled across the country, while the home team did not travel ($n = 101$). In these games, the visiting team did four points better ($p = 0.07$) when they traveled west to east rather than east to west, almost nullifying the home-court advantage. This effect, like similar findings for Monday Night Football games, may be due to West Coast visitors playing night games at an earlier time according to their "internal clock". An incidental finding in our study was that the home-court advantage decreased over 8 years, from about six points to three points (due to relatively lower field-goal percentages and fewer free throws by the home team). **Key Words:** Athletes—Performance—Circadian rhythms—Travel—Basketball.

The possible effects of disrupting circadian rhythms due to rapid crossing of time zones (jet lag) are much discussed but are difficult to measure (1). Professional sports teams that travel frequently and compete in events where outcomes are quantified provide a potentially useful source of data. Recht et al. (2) have studied major league baseball teams situated on either coast over three seasons. These authors restricted their analysis to games played 2 days before and after transcontinental travel (5% of games; approximately 50 games). They concluded that west to east travel by the visiting team significantly worsened their performance and cited evidence from the literature that resynchronization of circadian rhythms occurs more rapidly for east to west travelers. Smith et al. (3) studied 63 professional Monday Night Football games between West and East Coast teams. They concluded that West Coast teams were favored regardless of where games were played; the home-field advantage was nullified for Monday night games on the East Coast. These authors believed their findings were consistent with a circadian effect. Monday night games begin late (9 p.m.). The internal clock of the West Coast teams playing on the East Coast would be only 6 p.m., a time of better relative performance compared to the East Coast team. In contrast, for the East Coast teams traveling to the West Coast, their internal clocks would be set at midnight for a 9 p.m. game, a time of relatively worse performance compared with the West Coast team.

We have studied the effects of travel and rest among professional basketball teams. The questions of interest were whether patterns of travel and rest affected performance and, specifically, whether travel over more time zones or in a particular direction adversely affected performance.

METHODS

We obtained data on all regular season National Basketball Association (NBA) games over eight seasons (1987–1988 through 1994–1995) via a commercial distributor of sports information on the Internet (Computer Sports World, Boulder, CO). The regular season consists of 82 games. Patterns of travel and, presumably, performance differ during the playoffs, and these games were not considered. During the 1987–1988 season, there were 23 teams in the NBA,

Accepted for publication February 1997.
Address correspondence and reprint requests to Kyle Steenland, Ph.D., National Institute for Occupational Safety and Health, Centers for Disease Control, Cincinnati, OH 45226, U.S.A.

increasing to 25 in 1988–1989 and to 27 for the rest of the period.

Each game was an observation. There were a total of 8,610 games, but the first game of the season could not be modeled due to the lack of a prior game (see below), resulting in the use of 8,495 observations for the regression model. The outcome in the model for each game was the difference in score between the home team and the visiting team. The current record of the home team and the visiting team at the time of the game was included in the model (percentage wins). We also tried using a team's record for the entire prior season in modeling the first 10 games of the season (afterwards using the current record), but it did not improve prediction. The Las Vegas point spread was also tested instead of team record as a predictor of outcome but did slightly less well than team record. We included a variable for season (eight categories) in the model. We tested a variable for month within season, but it was not an important predictor and was omitted.

We created a variable for days between games for both home and visiting teams. To analyze effects of direction and distance of travel, we divided the United States into three zones based on latitude (east–west dimension). Teams located in Salt Lake City, Denver, Phoenix, Houston, San Antonio, and Dallas were considered in the middle zone, while other teams were considered in west or east zones.

For a given game, a team could have 1) not traveled at all, 2) traveled within a zone, or 3) traveled across one or two zones. "Travel" variables were created for home and visiting teams that had six levels for the home team [no travel, travel within zone, travel across one zone (east–west or west–east), travel across two zones (east–west or west–east)] and five levels for the visiting team (which by definition had to have traveled).

In a subanalysis, we analyzed games in which the visiting team had traveled from one coast to the other, while the home teams had not traveled. Both teams were required to have had equal days' rest after their prior game, and neither team could have played the day before (n = 101). The purpose of this analysis was to restrict variables to games most likely to be affected by disruption of circadian rhythms for the visiting team. While we did not know the time of day of the game, most games in the NBA are night games. We hypothesized that when the visiting team traveled west to east it would have an advantage relative to when it traveled east to west [consistent with the football findings (3)].

Regression analyses were conducted using PROC GLM in SAS (4). To account for correlated outcomes (teams playing each other more than once in a season), we also analyzed the data using SAS's PROC MIXED, which takes such correlation into account. Results were virtually identical, and here we present only the results from ordinary linear regression.

TABLE 1. *Descriptive statistics for NBA games*

Home-team victory	
All eight seasons	63.8%
1987–1988	67.8%
1994–1995	59.7%
Mean point spread, home vs. visitor	
All eight seasons	4.6
1987–1988	5.8
1994–1995	3.2
Mean points scored (home team)	
All eight seasons	107.8
1987–1988	111.1
1994–1995	103.0
Free throws attempted (percentage made)	
Home—all eight seasons	28.7 (75.7)
1987–1988	30.3 (76.7)
1994–1995	27.7 (73.7)
Visitor—all eight seasons	26.8 (75.4)
1987–1988	27.9 (76.5)
1994–1995	26.4 (73.5)
2-Point field goals attempted (% made)	
Home—all eight seasons	86.4 (48.3)
1987–1988	87.8 (49.3)
1994–1995	81.5 (47.3)
Visitor—all eight seasons	86.2 (46.6)
1987–1988	87.7 (47.1)
1994–1995	81.4 (46.1)
3-Point field goals attempted (% made)	
Home—all eight seasons	8.3 (32.1)
1987–1988	4.8 (29.9)
1994–1995	15.2 (36.1)
Visitor—all eight seasons	8.5 (30.6)
1987–1988	5.2 (27.4)
1994–1995	15.4 (35.4)
Mean days of rest, home team	2.24
Mean days of rest, visitor	1.95
Games with >1 day rest, home team	81%
Games with >1 day rest, visitor	65%
Travel before game, home team	
No travel	49%
Travel within time zone	34%
Travel across one zone	13%
Travel across two zones	4%
Travel before game, visitor	
Travel within time zone	73%
Travel across one zone	22%
Travel across two zones	5%

RESULTS

Table 1 shows descriptive results for the 8,610 games over the eight seasons (the statistics involving travel omitted the first games of the season and were based on 8,495 games). Statistics are given for all seasons and, when a trend is apparent, for the first and last seasons analyzed. Home teams won 64% of the

TABLE 2. *Regression models for home vs. visitor score*[a]

	Parameter[b]	p value
Model 1		
Intercept	1.12	0.08
Home record	25.52	0.0001
Visitor record	−22.33	0.0001
Home team rest >1 day	1.16	0.0016
Visiting team rest >1 day	−1.58	0.0001
Season		
1987–1988	2.38	0.0001
1988–1989	2.36	0.0001
1989–1990	1.65	0.0007
1990–1991	1.34	0.006
1991–1992	1.26	0.009
1992–1993	0.95	0.05
1993–1994	0.81	0.09
1994–1995 (referent)	0.00	na
Model 2		
Intercept	1.72	0.01
Home record	26.22	0.0001
Visitor record	−23.01	0.0001
Season		
1987–1988	2.54	0.0001
1988–1989	2.45	0.0001
1989–1990	1.75	0.0003
1990–1991	1.34	0.006
1991–1992	1.27	0.009
1992–1993	0.95	0.05
1993–1994	0.81	0.09
1994–1995 (referent)	0.00	na
Home team rest 1 day	0.00	na
Home team rest 2 days	1.06	0.002
Home team rest 3 days	1.08	0.01
Home team rest 4 or more days	0.57	0.27
Visiting team rest 1 day	0.00	
Visiting team rest 2 days	−1.55	0.0001
Visiting team rest 3 days	−2.25	0.0001
Visiting team rest 4 or more days	−1.13	0.05

[a] The model predicts the difference between home team score and visiting team score, based on 8,495 observations. The intercept is a constant term to which are added the effects of the variables. The r square (percent of variation explained) for both models was 26%; 8,495 observations.

[b] A negative coefficient for a variable for the visitor indicates a better score for the visitor; reverse for home team.

games played by an average margin of 4.6 points. Defense has apparently improved, as both home and visiting teams scored fewer points over time. The percentage of games won by the home team, and the winning margin, decreased significantly during the 8-year period. The decrease was primarily a function of a lower percentage of field goals made and of fewer free throws attempted by the home team. On average, the home team had more days off after their previous game than did visiting teams.

Table 2 shows the regression modeling results. Model 1 indicates that both home and visiting team benefited significantly from having more than 1 day between games (1.1 point improvement for the home team, 1.6 point improvement for the visitor team). This improvement in performance with more days between games was consistent across the eight seasons considered. Model 2 categorizes further the days between games and shows that the beneficial effect tended to peak with 3 days between games for both home and visiting teams, declining after ≥4 days between games.

TABLE 3. *Linear regression model for home vs. visitor score restricted to games in which the visitor travels across country, the home team does not travel, and both teams have equal days rest (≥2 days rest)*[a]

	Parameter	p value
Intercept	6.28	0.16
Home record	21.18	0.0003
Visitor record	−33.33	0.0001
Visiting team, east–west	0.00[b]	na
Visiting team, west–east	−4.03	0.07

[a] The model predicts the difference between home team score and visiting team score based on 101 observations. The intercept is a constant term to which are added the effects of the variables. Season was not a significant predictor of outcome for these data.

[b] East–west travel is the reference category.

We then conducted analyses (not shown) adding "travel" variables for direction and distance of travel. There were no consistent trends, suggesting that a greater distance traveled or the direction of travel decreased performance after controlling for days between games. Of the nine travel variables (combinations of direction and distance for home and visitor), only one was significant at the 0.05 level, indicating a positive effect for a visiting team traveling west to east across the country.

To further investigate this last finding, and to investigate the hypothesis advanced in a prior analysis of Monday Night Football games (3), we then restricted the data to games in which the visiting team traveled across the country, the home team had not traveled, and both teams had equal rest with at least 2 days between games. Results are shown in Table 3. The visiting team did better when it traveled west to east rather than east to west (borderline statistical significance, $p = 0.07$). The visitor scored approximately four more points relative to the home team, with west to east travel rather than east to west travel, almost nullifying the home-court advantage.

DISCUSSION

We found that performance for both home and visiting teams improved with more than 1 day between games, peaking with 3 days between games, and beginning to tail off with 4 days or more between games. The pattern conforms to intuition. Performance with only 1 day between games is affected negatively, perhaps because of lack of sleep or perhaps because of lack of time for musculoskeletal recovery. The visiting team, which is on the road and subject to repeated

travel, is affected more than the home team. The tailing off of improvement with more rest is presumably due to players starting to lose "sharpness" with too many days off. The increase in scores by 1.1 points for the home team and by 1.6 points for the visiting team with more than 1 day rest is an important improvement; in 1994–1995, on the average, there was only a 3.2-point difference between winner and loser in NBA games. Home teams get somewhat more rest between games (averaging 2.24 days vs. 1.95 days for visitors), which contributes to the home-court advantage.

On the other hand, we found few effects of direction or distance of travel after adjustment for the number of days between games. The only significant finding was that the visiting team traveling from coast to coast in a west to east direction performed significantly better than expected. We conducted a subanalysis to analyze this finding further and to mimic the analysis by Smith et al. (3) for Monday Night Football games. In this analysis, we restricted the data set to 101 games in which the visiting team traveled coast to coast, while the home team had not traveled. The visiting team again showed improved performance relative to the home team when the visitor traveled west to east, but not when it traveled east to west. This finding is consistent with the analysis of Monday Night Football games and might be due the visiting team playing night games at times of peak performance (based on their internal clock) when they traveled west to east, but not when they traveled east to west.

We could not duplicate the findings from baseball games in which one team had traveled coast to coast (2). In that analysis, the home team did relatively better when the visiting team had traveled west to east. The authors of the baseball analysis cited literature indicating that resynchronization of circadian rhythms is more difficult with west to east travel. Baseball teams usually stay in one place for a four-game series, and games are not as consistently played at night, so resynchronization may be more important than the question of playing night games at times of peak performance (prior to any resynchronization).

Our finding that the home-court advantage has been diminishing over time was unanticipated. It was accounted for by a relative decrease in field-goal percentage and a decreased number of free throw attempts for the home team versus the visitor. It is possible that the increased mobility of players in the NBA over time, with increased free agency, has contributed to a diminishing of the home-court advantage. Another possibility is the changing standards for referees over time, as suggested by fewer fouls called on the visitor over time.

In summary, we found a pronounced effect in which fewer days between games, and presumably less rest, negatively affected performance for both home and visiting teams. Regarding circadian rhythms, in an analysis of (mostly night) games in which the visitor had traveled coast to coast, we did find some evidence that performance was improved for the visiting team when they traveled west to east, but not when they traveled east to west.

Acknowledgements: Roger Cole of the University of California at San Diego and Joe Hurrell of NIOSH kindly provided comments on the manuscript.

REFERENCES

1. Comperatore C, Krueger G. Circadian rhythm desynchronosis, jet lag, shift lag, and coping strategies. *Occ Med Rev* 1990;5:323–42.
2. Recht L, Lew R, Schwartz W. Baseball teams beaten by jet lag. *Nature* 1995;377:583.
3. Smith R, Guilleminault C, Efron B. Peak athletic performance time and circadian advantage in professional athletes. *Sleep Res* 1996;25:573.
4. SAS Institute, Inc. *SAS user's guide: statistics,* version 6.07). Statistical Analysis Systems Institute: Cary, NC, 1991.