WHOOP

CASE STUDY // THE EFFECT OF TRAVEL ON SLEEP AND RECOVERY

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Summary

Since 1979, 62.2% of NBA games were won by the home team.[1] While home court advantage is ubiquitous across all sports and all levels of competition, its causes are poorly understood.[2] One oft provided explanation of home team advantage is that the home team is spared the rigors of travel. Studies have attempted to quantify this effect by comparing home and away performances[3] and by controlling for factors like days on the road and rest days between games[4]; however, none have had the tools to rigorously quantify the effects of home and away games on objective measures of athlete recovery.

This case study attempts to untangle two phenomena (1) the effect of travel on sleep and recovery and (2) the effect of changing time zones on sleep and recovery.

For this analysis, we used data collected using the WHOOP Performance Optimization platform. WHOOP provides each of its users with a daily Recovery Score, a summary statistic encompassing several metrics known to be predictive of an athlete's readiness to take on strain. These include resting heart rate, heart rate variability, and various measures of sleep quality and sufficiency. WHOOP additionally provides thorough sleep analysis including time spent in bed, number of sleep disturbances, time taken to fall asleep, and a proprietary Sleep Score, which quantifies the percentage of needed sleep that an athlete attained.

By combining the data provided by WHOOP with the user's competition schedule data, we were able to match our Recovery and Sleep Scores with the city (and therefore timezone) in which they occurred. This case study presents data collected in a single individual over the course of 69 competition games occurring in all 4 US time zones from October 2015 through March 2016.

Data Analysis

Of the 69 games eligible to be considered in this analysis, WHOOP data was available for 41. Those 41 were subdivided in two ways, first by timezone (**Table 1**) and second by their Euclidian (straight-line) distance from home (**Table 2**).

In order to establish the boundaries by which to group distances, two conditions needed to be satisfied (1) the number of distance groups should equal that of the timezone groups, and (2) each of the away groups should represent the same mile range.

Of the 41 games, 19 were home games (distance = 0). The furthest away game required travel across 2594 miles; the bins chosen were therefore 0 miles (home), 1-650 miles, 651-1300 miles, 1301-1950 miles, and 1951-2600 miles.

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[1] Economist, 2015
[2] Moskowitz and Wertheim, 2011
[3] Harville and Smith, 1994
[4] Entine and Small, 2007

Metric (units)	Home: Eastern	Away: Eastern	Away: Central	Away: Mountain	Away: Pacific
Recovery Score (%)	59.68	63.75	55.5	44.33	43.4
RHR (beats per minute)	52.37	55.42	50.5	56.67	55.2
HRV (milliseconds)	72.62	53.97	61.27	54.83	57.88
Sleep Score (%)	78.16	93.25	75	72	73.6
Time In Bed (hours)	7.54	8.93	7.1	8.29	7.25
Disturbances	9.84	13.17	11	11.33	11.2
Sleep Latency (hours)	0.3	0.19	0.27	0.34	0.29
Recovery Score Next Day (%)	56.42	44.33	40.5	38	33
HRV Next Day (milliseconds)	69.15	53.79	47.5	54.96	51.58

Table 1. Metric averages by timezone and home/away. All metrics shown are for the sleep and recovery period prior to the competition unless otherwise indicated by the words "Next Day".

We note that dividing the games in these two ways created non-trivial differences in which teams were grouped together. For example, because of the team's location within the Eastern Timezone, there are many cities in the Central Timezone that are closer than the farthest-away Eastern Timezone cities. Those cities, when measured by time zone, appear to be further; however, when measured by Euclidian distance, end up in a closer-distance grouping.

Metric (units)	Home	1 - 650 miles	651 - 1300 miles	1301 - 1950 miles	1951 + miles
Recovery Score (%)	59.68	75.17	48.78	59.5	43.4
RHR (beats per minute)	52.37	54.83	55.11	55.5	55.2
HRV (milliseconds)	72.62	61.93	47.69	66.95	57.88
Sleep Score (%)	78.16	95.33	82.67	84.5	73.6
Time In Bed (hours)	7.54	9.42	8.09	8.43	7.25
Disturbances	9.84	14	11.33	14	11.2
Sleep Latency (hours)	0.30	0.19	0.27	0.34	0.29
Recovery Score Next Day (%)	56.42	42.5	47.33	23	33
HRV Next Day (milliseconds)	69.15	48.31	60.14	37.1	51.58

Table 2. Metric averages by time distance from and home. All metrics shown are for the sleep and recovery period prior to the competition unless otherwise indicated by the words "Next Day".

Finding 1: Time Zones Crossed, Not Miles Traveled

Changing time zones had a stronger correlation with numerous Sleep and Recovery statistics than did miles traveled. For example, for both the WHOOP Recovery Score and the WHOOP Sleep Score, the coefficient of correlation, r2, was significantly higher for correlations with time zones crossed than with total miles traveled, by 24% and 174% respectively.

We see this also in the data presented in **Tables 1 and 2**, above. In the first two columns of **Table 1**, we see the scores associated with home games (first column) and scores associated with away games taking place in the analyzed users' home timezone (second column). Notice how the games in the Away: Eastern Timezone column and the Home column are much more similar to each other for key metrics like Recovery before and after the game than the values in the Away: Eastern Timezone column are to the Away: Central Timezone column.

Finding 2: There's No Place Like Home

No matter how you slice the data, by time zones crossed or miles traveled, recovery after a game day – as measured by HRV and by the WHOOP Recovery Score (the last two columns of **Tables 1 and 2**) - is significantly greater following home games than following any subgroup of away games. Next-day Recovery Scores are 16 percentage points greater following home games (56.42%) than following away games (40.55%), and next-day HRV measurements average 17 milliseconds greater following home games (69.15 ms) than following away games (52.87 ms).

Additionally, sleep quality – as measured by the average number of sleep disturbances – is consistently lower on nights before home games (average = 9.8) – presumably when the athlete is sleeping in his own bed – than on nights prior to away games of any distance or number of time zones away (average =12.3).

Finding 3: Travel Isn't All Bad

Interestingly, traveling does seem to have one fairly consistent benefit: prior to away games, the average time dedicated to sleep is 8.29 hours, a major jump from the 7.54 hours dedicated to sleep prior to home games. This makes the difference in Recovery Scores all the more interesting – despite more time dedicated to sleep, something that ordinarily strongly correlates with greater Recovery Scores, away games saw Recovery Scores roughly 4 percentage points lower than home games.

Daylight Savings Time

This case study attempts to analyze both independently and in concert the effect of traveling and the effect of changing time zones on various metrics of sleep and recovery. The best way to understand these effects is to examine cases in which only one of the two variables changes. In the data set discussed so far, we have many examples of traveling without changing time zones, but no examples of changing time zones without traveling. I therefore bring in one additional data set to allow for a more robust analysis than would otherwise be possible.

On 03.13.2016, we began Daylight Savings by moving our clocks one hour forward. The effect of this practice is physiologically similar to a one-hour timezone change. Analyzing the effect of Daylight Savings on recovery and sleep therefore allows for an analysis that would not otherwise be possible; namely, changing time zones without traveling.

In order to quantify the effect of a one hour timezone change in isolation from the effect of travel, I averaged the Recovery Scores of all WHOOP users on the morning of March 13th and compared them to the average Recovery Scores of the same individuals on the week leading up (but not including) March 13th. On the first morning of Daylight Savings, the average Recovery Score was 54.8%, on the week prior, the average Recovery Score was 59.6%. This change is not statistically significantly different from the Recovery change caused by changing time zones via travel in the data set analyzed above.

Why This Matters

The analysis presented above represents the start of a larger effort to understand the effect of travel on athlete recovery. The metrics that go into the WHOOP Recovery Score – heart rate, heart rate variability (HRV), sleep quality, sleep duration sufficiency – have all been independently shown to correlate with other measures about which athletes care most. To name a few, two independent studies in 2011[5] and 2014[6] showed that sleep duration is correlated with rates of injuries, and numerous studies have shown that resting HR and HRV are powerful predictors of athletic performance[7,8,9,10]; in a white paper released by the WHOOP Department of Physiology and Analytics earlier this year, we additionally showed that the WHOOP Sleep Score is correlated with athlete self-reported performance[11].

A 2009 paper looking into home and away injury rates in the Iranian Premier League found that athletes competing in away games experienced 72.01 injuries per 1000 hours of play while athletes competing in home games experienced only 57.6 injuries per 1000 hours of play[12].

Understanding the causes of recovery-suppression on the road is the first step in offsetting them. If these effects can be effectively offset, we can expect to see fewer injuries in traveling athletes and improve the competition performance of traveling athletes, leading to a safer and fairer competition.

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[5] Mah et al., 2011
[6] Milewski et al., 2014
[7] Vasterinen et al., 2011
[8] Kiviniemi et al., 2007 and 2009
[9] Plews et al., 2013
[10] Uusitalo et al., 1998
[11] Breslow, 2016
[12] Rahnama et al., 2009

Implications For Future Research

The analysis presented above is the first to show the correlation between WHOOP metrics and travel. It also attempts to tease apart the effects of travel from the effects of changing time zones, a distinction not often made in literature analyzing the effect of travel on athletes.

We recognize that the amount of data analyzed in this case study is small and that follow up research will be necessary before robust conclusions can be drawn; however, we find this data to be an extremely encouraging indication that travel and crossing time zones have independent effects on athlete recovery, and therefore on athlete readiness to perform. Further elucidating these differences can result in more intelligent travel recommendations, which would have the dual benefit of decreasing the physiological stress of travel and improving performance of away-team athletes.

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