Effect of time zone and game time changes on team performance: National Football League

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ABSTRACT

JEHUE, R., D. STREET, and R. HUIZENGA. Effect of time zone and game time changes on team performance: National Football League. *Med. Sci. Sports Exerc.*, Vol. 25, No. 1, pp. 127–131, 1993. To determine the effect of time zone and game time changes on NFL team performance, win-loss records from 1978–1987 were analyzed. Twenty-seven NFL teams were grouped by time zone and possible anti-jet lag adjustments. Among all intra-time zone rivals, home teams won 56.6%, away teams won 43.8%, for a home vs away winning percentage change of −12.8% ($P < 0.001$). West teams ($N = 5$) displayed fluctuations in home vs away team performance in association with trans-meridian travel. The change in winning percentage was found to be 0.0% vs West teams, −14.1% vs Central teams ($N = 8$) ($P < 0.05$), −16.3% vs East ($N = 14$) ($P < 0.05$) for West teams ($N = 4$) flying about 42 h pregame and +2.3% vs East for the one West team advancing practices 3–4 h to match East coast game time in addition to 48 h pregame flights. For night games within the same time zone, home vs away team winning percentage changed −23.8% ($P < 0.01$). West teams displayed uniformly high home winning percentages (75.0% and 68.4%) when playing Central and East teams, respectively, with little or no fall in away winning percentages (67.7% and 68.8%). For day games, a 3-h phase advance may decrease West coast team performance. In one small subset, anti-jet lag adjustments appeared to eliminate the expected decrement in performance. For night games, West coast teams, whether home or away, appear to be at a distinct advantage over East and Central teams.

ERGOGENIC AID, HOME FIELD ADVANTAGE, ATHLETES AND TRANS-MERIDIAN TRAVEL, JET LAG

Professional athletes are constantly searching for a competitive edge. Manipulating circadian rhythms may offer one such competitive advantage.

Circadian rhythms are daily cycles of physical and psychologic parameters such as body temperature, blood cortisol levels, and alertness (sleep-wake cycle). Each parameter peaks and ebbs at a characteristic time each day. Most parameters influential for athletic performance, such as grip strength, maximal ventilation, oxygen consumption rate, and tolerance to an all-out effort are closely related to the body temperature curve, which peaks in the late afternoon (13,20). Researchers (3,4,18) have demonstrated better late afternoon performance for swimming and rowing events when compared with those attempted in the morning. In fact, a disproportionately large number of world records have been broken in the late afternoon. In addition to endogenous rhythms, peak athletic performance appears linked to individual phase types (morning persons or larks vs evening persons or owls), the degree of internal rhythm sychronization (17), and external factors such as intensity of exercise, light, temperature, eating patterns, and social activities (16).

Air travel across multiple time zones desynchronizes the well-orchestrated endogenous rhythms by acutely offsetting the internal rhythms (i.e., sleep-wake cycle) with external cues (i.e., light-dark cycle). Decreased athletic performance has been documented under these conditions (6,15,21). Athletes may experience insomnia, poor mental and psychological task performance, reduced appetite, and multiple body complaints such as fatigue, apathy, weakness, and headaches.

The direction of travel and the number of time zones crossed are two major factors influencing the duration and magnitude of depressed athletic performance resulting from air travel across time zones. When travel is in a westward direction, the length of the day is extended and the body's circadian system must undergo a phase delay (lengthen). This is a natural direction for the body to adjust. It has been shown that humans, isolated from all environmental and light cues, display internal rhythms of about 25 h (12). In contrast, with travel in a eastward direction the length of the day is shortened and the circadian system must undergo a phase advance (shorten) to resynchronize. With the body demonstrating a natural tendency toward a period longer than 24 h, it is more difficult for the body to adjust itself to advances in daily rhythms. Thus, adjustment to eastward travel is more difficult (20). It has been suggested that at least three or more time zones must be crossed before the deleterious effects of jet-lag are evident (6,15).

A consistent home field advantage has been noted in

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a variety of amateur and professional sports dating back to the 1880s. From 1982 to 1984, in a comparison of major American professional sports, home advantage ranged from 53.6% in baseball to 65% in soccer (14). Multiple home field advantage hypotheses have been forwarded, mainly related to fans, familiarity, fatigue, and fairness (referees).

The purpose of this study was to determine home field advantage within respective time zones, then to determine whether contemporary professional football teams might be adversely affected by air travel across multiple time zones or by variable event times (i.e., day games vs night games).

METHODS

All 28 NFL teams were grouped by time zones for day, night, and postseason games; West ($N = 5$), Mountain ($N = 1$), Central ($N = 8$), and East ($N = 14$). Since the mountain time zone only consisted of one team that is located at a high elevation, itself being documented as having a negative effect on performance (8), that team was not used for comparison of day or night games.

For day games, subgroups were established for West and East teams that made anti-jet lag adjustments. Some teams altered their travel patterns over the years, being examined in such a manner that it resulted in their being in one subgroup for a few years, another subgroup in other years, or not fulfilling the criteria for any group. Other teams resettled in different time zones during the period of this study. This explains why the number of teams for the two East subgroups is more than the total number of teams in that time zone, why the number of games played by the West subgroups does not equal that of all the games played by that time zone, and why some home and away winning percentages do not add up to 1.0. Travel patterns, (i.e., fields, equipment, and rules) did not change much for the rest of the teams over the time period being examined. This resulted in four West coast teams (West-1) who had usual afternoon practice time sessions (about 13:45 h) and departed for Central and East coast games about 42 h pregame time. One West coast team (West-2) moved practice 3–4 h earlier to match the start time of East coast games but made no practice adjustment for Central games. They departed for Central games about 42 h in advance and for East games about 48 h in advance. Nine East teams (East-1) traveled 24 h in advance to West coast games while five East teams (East-2) traveled 48 h in advance. A special subgroup (Yearly) was established from 1966 to 1989 for two West teams and one East team that have played in home and away series every year since 1966.

The effect of travel across time zones on NFL team performance was then evaluated by comparing win-loss percentages when teams were at home and away while playing teams from the West, Central, and East time zones. To determine whether differences in observed performance were statistically significant, a series of Chi-square analyses was computed. Nonparametric analyses were selected since the frequency data and sample sizes did not meet parametric analysis standards of normality, heterogeneity of variance, or random selection of samples (19).

Since home field advantage may be less of a factor in championship games (2) and since every team, in theory, has a slightly different path for reaching the playoffs and Super Bowl (the better teams have "harder" schedules), these games were used only to indicate the "possible" strengths of the respective team groups by time zone. The same participation percentage of teams from each time zone in playoff and Super Bowl games as they account for their respective percentage of teams in the NFL was obtained.

RESULTS

Day games. When teams from identical time zones played day games, home teams won 56.6%, away teams 43.8%, ($P < 0.001$). Thus the absolute winning percentage change (Home winning % + [Absolute winning % change] = Away winning %) is −12.8.

West teams ($N = 5$) displayed absolute winning percentage changes when going from home to away of 0.0% vs other West teams, −14.1% vs Central teams ($P < 0.05$), and −9.8% ($P < 0.02$) vs East teams (Table 1).

West-1 teams ($N = 4$) displayed absolute winning percentage changes of +4.8% for West, −9.2% for Central, and −16.3% ($P < 0.05$) for East away games (Table 1).

The West-2 team ($N = 1$) displayed absolute performance changes of −11.0% for West, −26.7% for Central (no practice adjustments, 42-h pregame departure time), and +2.3% for East (3–4 h phase advance ad-

TABLE 1. West teams—day game winning percentages.

Performance	Versus West Time Zone	Versus Central Time Zone	Versus East Time Zone
West teams ($N = 5$)			
Home	0.500 (66)*	0.660 (103)	0.622 (127)
Away	0.500 (66)	0.519 (104)	0.524 (127)
Difference	0.0%	−14.1%**	−9.8%
West—1 teams ($N = 4$)			
Home	0.489 (59)	0.658 (79)	0.674 (89)
Away	0.537 (56)	0.566 (74)	0.511 (95)
Difference	+4.8%	−9.2%	−16.3%**
West—2 teams ($N = 1$)			
Home	0.643 (14)	0.688 (16)	0.542 (24)
Away	0.533 (15)	0.421 (19)	0.565 (23)
Difference	−11.0%	−26.7%	+2.3%

* ( ) Designates the number of games.
** Statistically significant ($P < 0.05$).

justment in practice times for the week prior to game, 48-h pre-game departure time) away games (Table 1).

Two West teams (Table 2) have had a yearly home and away series with the same East Coast club for the last 23 yr. The West Coast teams displayed a winning percentage change of −19.7% ($p < 0.05$) (home 78%, away 58.3%, 84 games evaluated).

Central teams ($N = 8$) displayed absolute home vs away performance changes of −12.1% ($P < 0.1$) for West, −14.7% ($P < 0.01$) for Central, and −14.3% ($P < 0.001$) for East (Table 3).

East teams ($N = 14$) displayed winning percentage changes of −13.8% ($P < 0.001$) for Central and −13.9% ($P < 0.001$) for East away games (Table 4).

East-1 teams ($N = 11$) displayed winning percentage changes of −10.2% (NS) for West, −15.0% ($P < 0.01$) for Central, and −13.7% ($P < 0.001$) for East away games (Table 4).

East-2 teams ($N = 5$) displayed absolute performance changes of −11.9% for West, −10.4% ($P < 0.2$) for Central, and −15.2% ($P < 0.02$) for East away games (Table 4).

Night games. When teams from identical time zones played night games, home teams won 61.9% ($P <$ 0.001), with away teams showing a winning percentage change of −23.8% (West = −21.8%, Central = +27.2%, East = −36.0%).

West coast teams ($N = 5$) displayed uniformly high home field winning percentages (75.0% and 68.4%) when playing Central ($N = 8$) and East ($N = 14$) games, respectively, with little or no falloff in away winning percentages (67.7% and 68.8%) (Table 5).

Post season. In attempting to determine team strengths by time zone, we looked to see if either West, Central, or East teams were appearing in post season play more or less frequently than expected (i.e., East Coast teams make up 14 of the 28 teams; it is expected that approximately one-half of the play-off spots should go to East Coast teams.) West Coast teams ($N = 5$) appeared in more post season and Super Bowl games than expected (+6.6% and +7.1%, respectively). Central teams ($N = 8$) were "underrepresented" (−4.7% and −18.6%), and East teams ($N = 14$) displayed a change of (−2.9% and +5.0%) for playoff and Super Bowl participation percentages, respectively (Table 6).

DISCUSSION

The combined results of intra-time zone play reveal sizeable home field advantages. The 56.6% home team winning percentage over the 10-yr study period is com-

TABLE 2. Yearly West vs East home and away series, 1967–1968.

West—yearly ($N = 2$)			
Home	—	—	0.780 (42)
Away	—	—	0.583 (42)
Difference	—	—	−19.7%**

*( ) Designates the number of games.
** Statistically significant ($P < 0.05$).

TABLE 3. Central teams—day game winning percentages.

Performance	Versus West Time Zone	Versus Central Time Zone	Versus East Time Zone
Central teams ($N = 9$)			
Home	0.467 (107)*	0.574 (156)	0.551 (312)
Away	0.346 (107)	0.427 (158)	0.408 (310)
Difference	−12.1%	−14.7%**	−14.3%**

*( ) Designates the number of games.
** Statistically significant ($P < 0.05$).

TABLE 4. East teams—day game winning percentages.

Performance	Versus West Time Zone	Versus Central Time Zone	Versus East Time Zone
East teams ($N = 14$)			
Home	0.476 (127)*	0.581 (285)	0.572 (498)
Away	0.371 (124)	0.443 (296)	0.433 (499)
Difference	−10.5%	−13.8%**	−13.9%**
East—1 teams ($N = 11$)			
Home	0.458 (95)	0.571 (203)	0.553 (368)
Away	0.356 (90)	0.421 (214)	0.416 (359)
Difference	−10.2%	−15.0%**	−13.7%**
East—2 teams ($N = 5$): adjusted travel times for west games			
Home	0.531 (32)	0.604 (82)	0.627 (130)
Away	0.412 (34)	0.500 (82)	0.475 (140)
Difference	−11.9%	−10.4%	−15.2%**

*( ) Designates the number of games.
** Statistically significant ($P < 0.05$).

TABLE 5. Night game winning percentages.

Performance	Versus West Time Zone	Versus Central Time Zone	Versus East Time Zone
West teams ($N = 5$)			
Home	0.609 (23)*	0.750 (8)	0.684 (19)
Away	0.391 (23)	0.677 (12)	0.688 (16)
Difference	−21.8%	−7.3%	+0.4%
Central teams ($N = 8$)			
Home	0.333 (12)	0.364 (11)	0.727 (22)
Away	0.250 (8)	0.636 (11)	0.417 (24)
Difference	−8.3%	+27.2%	−31.0%**
East teams ($N = 14$)			
Home	0.313 (16)	0.583 (24)	0.680 (50)
Away	0.316 (19)	0.227 (22)	0.320 (50)
Difference	+0.3%	−35.6%**	−36.0%**

*( ) Designates the number of games.
** Statistically significant ($P < 0.05$).

TABLE 6. Post season "championship" game results of NFL teams grouped by time zone.

Variable	West ($N = 5$)	Central ($N = 8$)	East ($N = 14$)
Percentage of total NFL teams	17.8	28.6	50.0
		Playoffs	
Games played	42	41	81
Participation percentage	24.4	23.8	47.1
Percentage difference	+6.6	−4.7	−2.9
		Super Bowls	
Games played	5	2	11
Participation percentage	25.0	10.0	55.0
Percentage difference	+7.1	−18.6	+5.0

parable to the 55.0% and 54.4% previously reported for the 1982–1984 (14) and the 1974–1976 NFL seasons (5). On subgroup analysis, no such home field advantage was seen for West teams. This may be due to differences in sample size, namely 132 West vs West games compared with 314 Central vs Central and 997 East vs East games. Alternatively, it may reflect increased intra-time zone travel for Central and East teams compared with West teams. Another possible explanation is the West teams were stronger. West teams outperformed the Mountain, Central, and East teams as suggested by their respective participation percentages in post season play (Table 6). It has reported that highly trained and motivated athletes are less affected by jet lag (1,7). Perhaps more successful teams are less affected by other physical and psychological factors responsible for "home field" advantage.

Travel by West teams to the East Coast (3-h time advance) or Central time zone (2-h time advance plus 1-h game time advance; i.e., both Central and East coast games typically start simultaneously at 13:00 h EST) showed a decrease in performance compared with intra-time zone away games (Table 1). This is consistent with a deleterious effect of jet lag on team performance. Unfortunately, most West teams play the East teams only sporadically (A West team typically only plays a particular East team about once every 3 yr), which may introduce an unseen bias. Therefore three (two West and one East) long-time yearly home-away rivalries were examined. From 1966 to 1989, West away teams showed a −19.7% change in home vs away performance for day games (78.0% at home compared with 58.3% when away) (Table 2). This was a significant decrement in performance compared with any intra-time zone home vs away comparison.

Although the sample size is small, subgroup analysis of the West-2 team further supports an influence of time zone change. West-2 made adjustments for East games (advanced practices up three or more hours and departed a full 48 h pregame time) and displayed no change in performance with travel to the East Coast. This is in marked contrast to the −26.7% absolute winning percentage change noted for when travel to the Central time zone, where no practice adjustments were made and the flight departed 42 h pregame time.

On the other hand, one can argue that both East and Central teams show high intra-time zone home vs away decrements (about −14.0%) with similar transmeridian travel decrements (about −14.0%) that are in the same order of magnitude as West-1 vs East with a home vs away change of −16.3%. Although this decrement is what may be expected for Central and East teams, this is a large decrease in performance for West teams' compared intra-time zone travel (0.0%).

Travel by Central or East teams demonstrated little or no change in winning percentage decrements, irrespective of the East subgroup (East-2) traveling early to West games. This supports the theory that adaptation or resynchronization (if truly important over three meridians) occurs more rapidly with westbound travel. It is postulated that it takes 30–50% less time to readapt following westward flights (phase delay) than after eastward flights (phase advance) (9,10). Generally it takes about 1 d to adjust for each eastward time zone crossed, and only about two-thirds of a day for westward travel.

Finally, although the number of night games is small and the games played are nonrandom (ABC television picks out games its staff feels will maximize ratings with minimal concern to geographic equality), there is a trend showing a high absolute performance change during intra-time zones games. Most notable is the consistently high winning percentage displayed by West teams, irrespective of being home or away when playing either Central or East teams (Table 5). If usual afternoon game and practice times correspond to peak performance times in these athletes, then Central and East teams must actually phase delay 7 or 8 h, respectively, compared with a 5-h phase delay by West teams for all night games. Additionally, with the recent advent of longer games, East and Central teams find themselves playing to times somewhere between 0000 and 0100 h local time. This is at the lower ebb of multiple mental and physical tasks (11). The drop in physical and psychological variables important to the athlete appears to be nonlinear as the night time "0200 h ebb" is approached. Therefore, the West teams' advantage home and away when playing Central and East teams may enlarge in the later stages of the game.

CONCLUSIONS

1. The magnitude of the day game decrement in West coast team performance when traveling to the East coast or Central time zones indicates "jet lag" may affect NFL team performance. This finding deserves further study.

2. The high winning percentage of West coast teams home and away during night games suggests either an advantage in playing games 3 h closer to typical practice times and/or a disadvantage for playing late at night/early morning when body rhythms approach their daily low.

3. Maneuvers that may help minimize the deleterious effects of circadian dysrhythmia on NFL team performance should be examined.

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