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Effects of Age and Travel on National Football League Quarterback Performance: A Correlational Study

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ABSTRACT

Background: Long-distance travel is common for professional athletes; thus, the impact of jet-lag on athletic performance is a relevant topic. Additionally, older individuals take longer to recover from exercise and post-travel fatigue; therefore, it is likely that age and travel affect performance. **Objective:** The purpose of this study is to investigate the effects of age and travel on NFL quarterback performance. **Method:** A correlational research design is used to examine the effects of age and travel on NFL quarterback performance. Data were collected from *pro-football-reference.com.* Quarterback ratings from the 2018 NFL season are analyzed with age, distance traveled, season week, and weeks since the team's bye week. The interaction of age and distance is also included to examine the impact of the age-distance relationship on performance. Regression analysis is used to predict quarterback ratings. **Results:** Season week ($p = 0.04$), weeks since a bye week ($p = 0.041$), and distance traveled ($p = 0.031$) have negative effects on quarterback ratings. The age-performance relationship in NFL quarterbacks is non-linear ($p = 0.018$), with quarterback performance decreasing during an athlete's 20s and then increasing during an athlete's 30s. Additionally, ratings of younger quarterbacks decrease with farther distances traveled, while the ratings of older quarterbacks increase with farther distances traveled ($p = 0.072$). **Conclusions:** Differences in performance by age with travel may be the result of different severities of jet-lag symptoms experienced by younger and older quarterbacks, as well differences in strategies for managing post-travel fatigue by athletes of different ages.

Key words: Athletic Performance, Fatigue, Football, Jet Lag Syndrome

INTRODUCTION

The National Football League (NFL) is the most recognized and valuable sports league in America (Das, 2020), and performance is a crucial factor when determining the success of a professional sports team (Cruickshank et al., 2013). Thus, professional teams are constantly seeking to increase performance capabilities of their players (Cruickshank et al, 2013). With such high popularity and profitability, NFL player performances are of interest to team owners and managers, as well as sports bettors and the general public. Furthermore, quarterbacks are considered the most impactful position to game outcomes due to their increased decision-making requirements compared to other positions (Brooks, 2015). Therefore, a successful quarterback is essential for team success (Brooks, 2015).

However, other factors besides athletic ability impact performance, including age and recovery (Allen & Hopkins, 2015; Brander et al., 2014; Nässi et al., 2017). Athletic performance increases with age until an athlete's mid-20s, after which performance begins to decline (Allen & Hopkins, 2015). Recovery is another factor that impacts individual performance, as high levels of physical stress without adequate recovery leads to decreased athletic performance and increased risk of injury (Nässi et al., 2017). Additionally, recovery time increases with age (Fell et al., 2008).

Long-distance travel disrupts the body's circadian rhythms, a condition commonly referred to as "jet-lag," which causes fatigue and longer recovery times in athletes (Kölling et al., 2016). With long-distance travel before competition common for professional athletes (Kölling et al., 2019), it is likely that frequent travel impacts athletic performance. Jet-lag recovery times also increase with age (Reilly, 2009); therefore, it is possible that the impact of travel on quarterback performance are more pronounced in older athletes. However, there is little research examining the combined effects of travel and age on athletic performance. Therefore, the purpose of this study is to determine the effects of travel and age on NFL quarterback performances by examining the effects of age, travel, and the age-distance relationship on NFL quarterback ratings.

The relationship of age and performance tends to be non-linear, creating an inverse U-shaped trend (Sturman, 2003). This age-performance pattern is expected to be similar in athletics (Allen & Hopkins, 2015; Lazarus &

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Harridge, 2017). Athletic performance increases with age until peak performance age is reached, after which performance begins to decline (Allen & Hopkins, 2015). Performance decreases generally begin in an athlete's late 20s and continue as age increases (Lazarus & Harridge, 2017). In fast-paced sports requiring more explosive movements like football, peak performance occurs sometime during an athlete's mid-20s (Allen & Hopkins, 2015). However, exact peak age differs individually and by the skill requirements of each position (Allen & Hopkins, 2015; Brander et al., 2014). Skills related to speed, explosive power, and reaction time peak in an athlete's early to mid-20s (Allen & Hopkins, 2015; Brander et al., 2014), while skills requiring higher levels of knowledge and cognitive performance peak in an athlete's late 20s or early 30s (Bradbury, 2009).

Recovery is another factor of performance that is affected by age (Fell et al., 2008; Nässi et al., 2017). Inadequate recovery time with high levels of physical stress causes performance declines and increases risk of injury (Nässi et al., 2017). Additionally, older athletes past the age of peak performance experience greater muscle soreness and take longer to recover from repeated exercise than younger athletes, causing declines in performance (Brander et al., 2014; Fell et al., 2008). Furthermore, as the body ages, it takes longer to recover from contact, which is another reason performance declines with age (Bradbury, 2009; Brander et al., 2014). This is also a crucial factor for athletes in high-contact sports, such as football.

Long-distance travel affects recoverability of athletes by causing jet-lag, a condition that interrupts the body's circadian rhythms and causes fatigue (Kölling et al., 2016). The body's circadian rhythm is an internal clock on approximately 24-hour cycles that is responsible for controlling sleep-wake cycles (Ho & Takahashi, 2008). Disruption to this cycle leads to disrupted sleep, daytime fatigue, and decreased physical and mental performance (Kölling et al., 2016). Because the circadian rhythm is based on the light patterns of a solar day (Ho & Takahashi, 2008), crossing multiple time zones causes jet-lag in approximately 89% of travelers (Iulia et al., 2012).

While there have been attempts to prevent jet-lag, solutions have only been effective at reducing the effects of jet-lag rather than fully preventing it (Reilly, 2009). Increased hydration, caffeine use, and phototherapy are effective in reducing the amount of fatigue caused by jet-lag; however, the severity of jet-lag symptoms differs with age, frequency of travel, and direction of travel (Iulia et al., 2012; Reilly, 2009). Although older individuals recover from the stressors of travel slower than younger individuals (Reilly, 2009), younger travelers have more severe symptoms of jet-lag than older travelers (Iulia et al., 2012). People who travel for professional reasons are also more likely to experience jet-lag than people who travel for personal reasons or for pleasure (Iulia et al., 2012). Additionally, symptoms of jet-lag increase with travel frequency, as those who travel more often experience more severe fatigue from jet-lag (Iulia et al., 2012). Therefore, elite athletes who travel frequently for training or competition experience jet-lag often, which can impact individual performance (Reilly, 2009). There is also evidence that the body takes longer to adjust when traveling eastward than when travelling westward (Iulia et al., 2012).

Although frequent travel by athletes causes jet-lag and impaired physical performance (Reilly et al., 1997), results on the effects of travel on game outcomes are mixed. While professional rugby players reported fatigue from traveling to games, there were no differences in the performance statistics of teams between home and away games (McGuckin et al., 2014). Contrarily, netball teams who traveled across two time zones scored less points than home teams (Bishop, 2004). Likewise, National Basketball Association (NBA) team performances decreased when traveling from east to west, with larger performance decreases associated with further travel (Steenland & Deddens, 1997). However, performance declines were not observed in NBA teams when traveling westward (Steenland & Deddens, 1997). Similarly, NFL teams who traveled from west coast to east coast performed better than teams traveling the opposite direction (Smith et al., 1997).

With the effects of travel on recovery and performance (e.g., Reilly et al., 1997; Smith et al., 1997; Steenland & Deddens, 1997), as well as the effects of age on jet-lag, recovery, and performance (e.g., Allen & Hopkins, 2015; Iulia et al., 2012; Kölling et al., 2016; Reilly, 2009), it is likely that both age and travel impact the performance of professional athletes. However, little is known about the relationship between age and travel on athletic performance. Therefore, the aim of this study is to investigate the combined impact of age and travel on NFL quarterback performance. Because older individuals take longer to recover from jet-lag than younger individuals (Reilly, 2009) and higher rates of travel cause more severe jet-lag symptoms (Iulia et al., 2012), it is likely that older athletes are more severely affected by jet-lag and travel than younger athletes, particularly when traveling farther distances. Thus, we hypothesize that (1) NFL quarterback performance increases until an athlete's mid-20s and then begins to decline; (2) NFL quarterback performance decreases as travel distance increases; and (3) NFL quarterback performance decreases with age while traveling far distances.

METHOD

Participants and Study Design

To determine the effects of age, travel, and the age-distance relationship on quarterback performance, a correlational research design is used. The study population is quarterbacks from the 2018 NFL season. Institutional Review Board (IRB) approval was not required, as all data is publicly available and there was no interaction with human participants.

Data Collection Procedure

NFL quarterback performance data for the 2018 NFL season were retrieved from pro-football-reference.com. The sample

included only quarterbacks who played in multiple games and excluded non-quarterbacks who threw passes during a game. The final sample included 527 quarterback-game observations.

Statistical Analysis

The dependent variable of interest is predicted quarterback rating (*rate)*, which is based on the products of variable means and coefficients. To test Hypothesis 1, quarterback age (*age*) is included as an independent variable. To examine whether a non-linear relationship exists between quarterback age and performance, the square of *age* is also included (age^2). Distance traveled to each game in miles (*dist*) is included to test Hypothesis 2. Finally, to examine the relationship of age and travel on performance and to test Hypothesis 3, an interaction variable is included that interacts *age* with *dist* (*agedist*). Control variables include the week of the season during which each game took place (*week*) and the number of weeks since the quarterback's bye week (*wkssincebye*). Average previous quarterback rating (*avgprevrate*) is included to predict *rate* based on these variables using regression analysis. Based on these variables, ordinary least squares (OLS) regression predicts quarterback ratings.

RESULTS

Table 1 presents summary statistics for the sample ($N = 527$), including the mean, standard deviation, minimum, and maximum for each variable. In this sample, quarterback age ranged from 21.203 years to 41.184 years, with an average age of 28.86 years. The distance traveled to games ranged from 0 miles to 2586.04 miles.

Regression outputs including and excluding playoff games are reported in Table 2. The variable *wkssincebye* was statistically significant, with quarterback rating decreasing by approximately one point for each week since a bye week, both during the regular NFL season excluding playoff games ($p = 0.080$) and throughout the entire NFL season including playoff games ($p = 0.041$). Additionally, the variable *week* was a statistically significant predictor of quarterback ratings, with quarterback ratings decreasing by approximately half a point each week throughout the regular season ($p = 0.08$) and the entire season ($p = 0.04$). The variable *age* was also statistically significant, predicting approximately a 10-point decrease in quarterback rating for each year, an effect that was observed both during the regular season ($p = 0.037$) and the entire season ($p = 0.023$). However, age^2 was also significant, providing evidence that there is a non-linear positive effect of age on quarterback rating that impacts quarterback ratings both during the regular season ($p = 0.032$) and the entire season ($p = 0.018$). Additionally, the variable *dist* is statistically significant, indicating that distance traveled has a negative effect on quarterback rating, both including playoff games ($p = 0.031$) and excluding playoff games ($p = 0.050$), with further distances travelled causing larger decreases in quarterback ratings. Finally, the variable *agedist* was statistically significant, showing that the interaction between age and distance affects predicted quarterback ratings during the regular season ($p = 0.034$) and the entire season ($p = 0.072$).

Table 1. Summary statistics of variables

Variable	Obs	Mean±SD	Min	Max
Rate	527	92.2006±28.1427	0	158.3
Avgprevrate	527	93.6695±1908586	2.8	158.3
Wkssincebye	527	5.35104±2.85254	1	14
Age	527	28.8605±5.48861	21.103	41.184
Dist	527	454.844±612.982	0	2586.04
Week	527	10.2903±4.9696	2	21

Obs = observations, dist = distance traveled in miles, wkssincebye = number of weeks since quarterback's bye week, avgprevrate = average previous quarterback rating

Table 2. OLS regression estimates for quarterback rate

	Including Playoffs		Excluding Playoffs	
	Coef.	Std. Err.	Coef.	Std. Err.
Avgprevrate	0.03974	0.07595	0.0452	0.0778
Wkssincebye	-1.0016**	0.48842	-0.9021*	0.51337
Age	-10.857**	4.75376	-10.439**	4.99081
Age^2	0.1889**	0.07942	0.17987**	0.08351
Dist	-0.0226**	0.01042	-0.0279*	0.01131
Agedist	0.00064*	0.00036	0.00083**	0.00039
Week	-0.564**	0.27367	-0.4929*	0.28681
Constant	221.025	68.5621		
Observations	527		503	
R^2	0.2529		0.2561	

*p < 0.1, **p < 0.05. agedist = interaction variable of quarterback age (age) and distance traveled (dist)

The interaction between age and distance travelled is shown in Figure 1. While younger quarterbacks' ratings decrease when traveling, older quarterbacks' ratings increase when traveling. Therefore, as age increases, quarterback performance with long-distance travel increases, indicating that older quarterbacks perform better with long-distance travel than younger quarterbacks.

For example, younger quarterbacks included in the sample, such as Baker Mayfield and Nick Mullens, both of whom were 23 years old during the 2018 NFL season, had significantly lower ratings after traveling to games. Mayfield's rating went from 100.1 to 70.7 after traveling nearly 2,500 miles from Cleveland to Oakland. Mullens experienced similar declines in ratings, from 112.8 to a season low of 62.1, after traveling from San Francisco to Tampa Bay. Contrarily, ratings of older quarterbacks Ben Roethlisberger and Eli Manning, who were 36 and 37 years old respectively during the 2018 season, increased after long-distance travel. Roethlisberger's rating increased from 96.26 to 130.2 when traveling over 2,500 miles from Pittsburgh to Oakland. Similarly, Manning's rating increased from 92.06 to 110.7 after traveling from New York to San Francisco, nearly 3,000 miles.

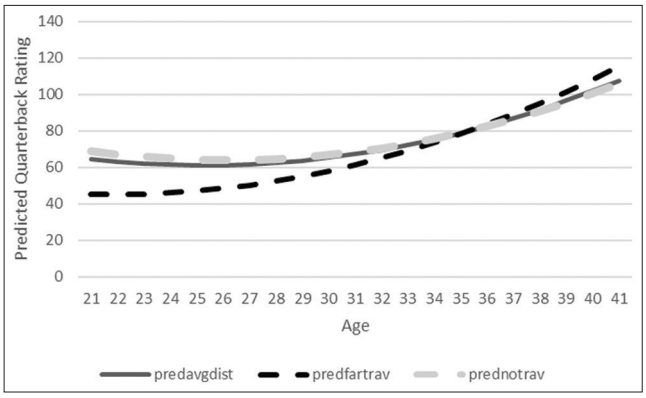

Figure 1. Predicted quarterback rating based on age and travel

DISCUSSION

The aim of the present study was to determine the effects of age and travel on NFL quarterback performance. We hypothesized that performance would decrease with age after peak performance age is reached and that further distances traveled would cause greater decreases in performance. We also hypothesized that older quarterbacks would perform worse when traveling far distances than younger quarterbacks. However, the regression analysis indicates that the age-performance relationship is non-linear, with performance decreasing until an athlete's late 20s and increasing again into an athlete's 40s, opposite of what was hypothesized. Additionally, while further distances traveled did cause decreases in quarterback ratings, this effect was only observed in younger quarterbacks. For younger quarterbacks, further distances traveled cause greater decreases in ratings. Contrarily, ratings increase with further distances traveled for older quarterbacks. These results provide evidence that jet-lag may impact quarterback performance; however, contrary to our hypothesis, it appears that jet-lag has more pronounced effects on younger quarterbacks. The amount of time since a team's bye week and the season week were also significant predictors of quarterback ratings, which could be indicative of changes in athlete recovery as the NFL season progresses.

Performance Throughout the NFL Season

Results of the present analysis show that quarterback ratings decrease each week as the NFL season progresses, including during the playoffs, indicating that performance decreases as the season progresses. This is unsurprising, as previous research has shown that athlete fatigue increases throughout a competitive season while energy, focus, and alertness decrease, causing performance decreases (Cormack et al., 2008; Gonzalez et al., 2012). Similarly, Varamenti et al. (2013) found that biomarkers of physical damage and stress increase as the competitive season progresses, which impacts the recoverability of athletes throughout a competitive season. Thus, decreases in quarterback ratings each week in the present study are likely the effect of a lack of full recovery in athletes as the season progresses and optimal recovery time increases.

Bazyler et al. (2017) found that a multi-week taper is an effective method for optimizing recovery to increase performance before competition in track and field athletes. Although this is difficult to implement when competition is weekly in sports like football, bye weeks provide a similar environment of extended recovery time. Furthermore, there is evidence that NFL teams defeat opponents by a larger margin following a bye week than teams not coming off a bye week (Foreman et al., 2016). Interestingly, in the present study, quarterback ratings decreased with each successive week since their team's bye week. However, it is possible that performance decreases multiple weeks after a team's bye week is also influenced by typical performance decreases as the season progresses. While players may receive optimal recovery during a bye week, they do not have the same opportunities for rest during non-bye weeks; thus, performance is likely to decrease the longer it has been since a team's bye week.

Quarterback Age and Performance

Peak performance age in a sport dominated by quick, explosive movements like football occurs in an athlete's mid-20s (Allen & Hopkins, 2015). While regression results indicate that quarterback ratings decrease by approximately 10 points with each increase in age, the variable age^2 also provides evidence that age and quarterback performance have a positive non-linear relationship. Based on this result, quarterback ratings decrease until an athlete's late 20s. However, this should be approximately peak performance age for quarterbacks, as the position requires high levels of cognitive performance and athletic skills (Bradbury, 2009). Interestingly, quarterback ratings then increase during an athlete's 30s and into their 40s. This pattern is opposite of the typical linear decrease in athletic performance as age increases past peak performance age (Allen & Hopkins, 2015; Lazarus & Harridge, 2017). Likewise, this result is opposite of the expected non-linear relationship of age and performance, where performance first increases with age and then declines (Sturman, 2003). While the result of the age-performance relationship in this study is inconsistent with previous findings (e.g., Allen & Hopkins, 2015; Lazarus & Harridge, 2017; Sturman, 2003), there are multiple possible explanations for this occurrence.

First, quarterbacks rely more heavily on cognitive abilities than other positions, skills that peak at later ages than physical skills (Bradbury, 2009). Therefore, one possible explanation for increases in quarterback performance at ages later than typical peak performance age is that the cognitive abilities of quarterbacks continue to increase with age. Older quarterbacks with more experience may have more developed neurocognitive skills and strategies, which could have a larger impact on their performance than the physical skills of younger quarterbacks, causing overall performance to increase during quarterbacks' 30s and into their 40s.

The predicted decrease in performance during a quarterback's 20s could also be a result of which quarterbacks are still in the NFL as they get older. Young quarterbacks with lower levels of performance will not remain in the NFL; therefore, higher performance levels will keep a quarterback in the NFL as they get older. While worse quarterbacks will not last long in the league, the best quarterbacks will continue to play as they get older. As a result, the oldest quarterbacks likely have the highest performance levels in order to keep playing as they age. Thus, quarterback performance may

appear to decrease mid-career, but this effect could also be the result of which quarterbacks are still playing at older ages.

Distance Traveled and Performance

Regression results also indicate that, generally, further distances traveled decrease quarterback ratings. Similar results have been found in professional basketball and netball, where further distances traveled had greater negative effects on team performance (Bishop, 2004; Steeland & Dedden, 1997). This makes sense, as further distances traveled cause greater circadian rhythm disruptions (Ho & Takahashi, 2008; Iulia et al., 2012), which cause decreases in athletic performance (Reilly, 2009). Long-distance travel could also decrease the amount of preparatory time and recovery time a traveling team has compared to a home team, which could impact performance and game outcomes.

Age-Travel Relationship

Results from the present study provide evidence that travel and jet-lag affect NFL quarterback performance; however, this seems to be true only for younger quarterbacks. Contrarily, older quarterbacks not only appear to handle travel better, but their performances increase with long-distance travel. This is interesting, as older individuals take longer to recover from jet-lag than younger individuals (Reilly, 2009). However, it is possible that older quarterbacks who have consistently traveled throughout multiple NFL seasons have developed strategies to minimize the effects of and recover from jet-lag, whereas younger quarterbacks may not be as accustomed to frequent long-distance travel prior to competition. Younger individuals also experience worse jet-lag symptoms than older individuals (Iulia et al., 2012); therefore, these more severe symptoms from long-distance travel may be the cause of performance decreases in younger quarterbacks. Although this study provides insight on the effects of age and travel on athletic performance, further research is necessary for a more comprehensive understanding of the combined impact of age and travel on performance.

Limitations and Future Research

This study only analyzed quarterback ratings from the 2018 NFL season, providing evidence from a single NFL season. Analyzing data from multiple seasons would provide further insight on the impact of age and travel on NFL quarterback performances and a more complete understanding of the age-travel relationship. Similarly, only the performances of quarterbacks were examined. Including players from multiple positions would provide more knowledge of the effects of travel on other positions, as well as examine trends of the age-distance relationship in other positions, which impact overall NFL team performance as well.

Although our results provide evidence that travel impacts younger and older quarterback performances differently, the reasons for this performance difference by age remains unknown. Therefore, more qualitative methods are needed to fully understand the results of this study, such as examining differences in strategies for managing jet-lag in young and old quarterbacks. Furthermore, results of this study are based only on distance traveled and do not include direction of travel, which has been shown to impact athletic performance (Smith et al., 1997; Steenland & Deddens, 1997). Examining the impact of direction of travel could also provide more insight on how age and travel impact NFL quarterback performances. Finally, research on the age-distance relationship in other sports would provide knowledge of how age and travel impact performance in other sports and lead to a more complete understanding of the effects of age and travel on overall athletic performance.

Practical and Theoretical Implications

Findings from the present study suggest that older NFL quarterbacks perform better than younger quarterbacks when traveling far distances to a game. Therefore, younger quarterbacks would likely benefit from establishing routines to minimize jet-lag when traveling. Additionally, coaches and managers should take these findings into consideration when preparing teams for long distance travel and make appropriate scheduling decisions to optimize rest and recovery prior to competition. Furthermore, these findings provide rationale for additional research on the relationship of age, travel, and performance, and thus can be used by scholars to further investigate how rest and recovery impact performance.

CONCLUSION

Results of this study provide insight on the age-performance relationship and the impact of the age-travel relationship on NFL quarterback performance. Contrary to the typical age-performance relationship, regression outputs indicate that NFL quarterback performance decreases during an athlete's 20s and then increases during their 30s and into their 40s. This could be the result of increases in cognitive performances at later ages, or the fact that older quarterbacks must perform at higher levels to continue playing in the league as they age. Additionally, results indicate that younger NFL quarterbacks' ratings decrease with long-distance travel, while older quarterbacks' ratings increase with long-distance travel. This could be the result of older quarterbacks having more travel experience, and therefore having effective strategies for managing the effects of jet-lag compared to younger quarterbacks. It is also possible that younger quarterbacks experience more severe symptoms of jet-lag compared to older quarterbacks (Iulia et al., 2012), causing decreases in performance when traveling. These findings have implications for NFL owners, coaches, and management, as well as sports bettors. Coaches and managers may take these findings into account when preparing quarterbacks for long-distance travel. Additionally, NFL team owners and sports bettors can benefit from these findings when predicting how a team or individual quarterback will perform when traveling.

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