Long-Term Mortality Effects of an NFL Career[*]
(Job Market Paper)

Tyler Williams
Department of Economics, MIT

Revised: November 14, 2012

Professional football is a high-profile dangerous industry. Most National Football League (NFL) players suffer concussions, ligament damage, or broken bones. However, for many young men, the perceived benefits of an NFL career – fame, high salaries, medical and training services, and utility from playing football – outweigh the perceived injury risk. Using mortality data on all NFL players born between 1937 and 1975 with at least three years' experience, I attempt to quantify this injury risk in mortality terms. Baron et al. (2012) report that NFL retirees have lower mortality than the age-matched general public, but NFL players are positively selected on many genetic characteristics, smoking rates, and physical fitness history. To reduce positive selection bias, I compare NFL retirees with short careers to retirees with long careers. Cox proportional hazard and OLS models yield no significant linear relationship between career length and mortality. Career-shortening injury histories may increase mortality, however, biasing these estimates downwards. To address this bias, I examine the early retirement margin, before most players can accumulate substantial injury histories. I estimate that mortality for players with careers longer than three years is about 40 percent higher than mortality for players with three year careers, assuming a constant proportional effect across all ages. For positions with a high risk of injury, the mortality hazard for players with more than three years' experience is more than double the hazard for three-year players.

[*] I am grateful to the MIT Labor/Public Finance Workshop and especially Christopher Walters, David Chan, Christopher Palmer, Amy Finkelstein, and David Autor for excellent feedback that helped shape this paper. I am also indebted to the George and Obie Shultz Fund at MIT for support for data acquisition. Most of all, I thank my advisors, Josh Angrist, Robert Stavins, and Heidi Williams, for their patience and valuable suggestions as this project evolved.

I. Introduction

Professional football is a high profile example of a dangerous industry. Most National Football League (NFL) players suffer some combination of concussions, ligament damage, and broken bones. However, for many young men, the perceived benefits of an NFL career – fame, high salaries, medical and training services, and utility from playing football, among other factors – outweigh the perceived injury risk. In this paper, I attempt to quantify this injury risk in mortality terms.

Several survey based studies suggest that NFL retirees have a poor quality of life. Forty percent of NFL retirees self-report arthritis pain compared with 11 percent of the similarly aged general population (Golightly et al., 2009). Concussions sustained while playing football are correlated with self-reported dementia and memory loss (Guskiewicz et al., 2005) and depression diagnoses (Guskiewicz et al., 2007), which are symptoms of Chronic Traumatic Encephalopathy (CTE). Known as "punch-drunk syndrome" in boxers, CTE causes brain degeneration, leading to memory loss, depression, impaired motor function, and, eventually, death. Numerous clinical studies (see, for example, Stern et al., 2011) have diagnosed CTE in athletes with a history of concussion. While these studies have generated substantial interest in the health effects of contact sports, they do not prove that playing in the NFL reduces quality of life or life expectancy. First, NFL players differ from the general population in many ways. Second, establishing a causal link between head injuries and CTE is difficult, since diagnosis must be done post-mortem and few brains have been made available for study. Third, concussion risk is just one aspect of playing in the NFL that may affect mortality.

Direct mortality analysis for NFL players is limited. The National Institute for Occupational Safety and Health (NIOSH) has published two reports (Baron et al., 1994, Baron et al., 2012) showing that NFL players live longer than the age-matched general population. However, in line with evidence relating CTE to concussions, the NIOSH observed higher death rates from brain degenerative diseases (CTE is often diagnosed as Alzheimer's, Parkinson's, or ALS) for NFL players compared to the general population (Lehman et al., 2012).

Again, these comparative studies likely suffer from omitted variables bias; NFL players have lower smoking rates, higher BMIs, better athletic ability and other genetic characteristics, and a stronger fitness history compared with the general population. This bias is an example of the "healthy worker effect": in most settings, employees have better health outcomes than the general population because a minimum health standard is required to maintain employment (see, for example, McMichael, Spirtas, and Kupper, 1974, McMichael, 1976, Carpenter, 1987). The NFL also provides health insurance to many retirees and disability payments to those who qualify. These benefits reduce the costs and increase the

incentives, respectively, for NFL retirees to obtain various health diagnoses. Because of these issues, the mortality effects of an NFL career remain unknown. I take a different approach to measuring mortality effects. Using data on game participation and mortality for all players born between October 1, 1937, and October 1, 1975 who played for at least three seasons, I compare mortality for players with shorter versus longer careers.

Estimating the relationship between career length and mortality reduces the contribution of some omitted variables, but may introduce other biases. First, players may have their careers cut short because they exhibit a lack of physical ability or effort. These characteristics likely increase mortality for players with short careers, biasing estimated effects of career length on mortality downwards. Second, injuries shorten careers (Edgeworth Economics, 2010). Injuries may increase mortality as well, biasing estimated effects downwards again. Third, players may depart from the NFL because they have a strong outside option. The value of a player's best outside option is probably negatively correlated with his mortality, biasing the estimates upwards.

Cox proportional hazard models yield no significant linear relationship between career length and mortality. The precision in these estimates is sufficient to rule out a 5 percent difference in mortality for each additional year played, depending on the subgroup studied. OLS estimates are similar, suggesting a slight decrease in mortality before age 40 for players with longer careers and no differences at older ages. These results contrast with estimates for Major League Baseball players showing that the correlation between career length and mortality is strongly negative (Abel and Kruger, 2006, Saint Onge, Rogers, and Krueger, 2008). Thinking of baseball as a control for ability selection and other effects, this comparison implies that the true mortality impact of a longer NFL career could be positive. Additionally, injuries are much more common and severe in football, suggesting that the football/baseball difference could be even greater.

To reduce the possible bias due to injuries and make a stronger case for a positive mortality effect, I investigate the early retirement margin, before most players can accumulate substantial injury histories. Specifically, I compare mortality for players who played only three years against mortality for those who played more than three years. Using Cox hazard models with constant proportional effects at different ages, I find that mortality for players with careers longer than three years is about 40 percent higher than mortality for players with three-year careers, stratifying on birth cohort, NFL entry cohort, and playing position and controlling for NFL draft selection number, height, and BMI. While these estimates may still be biased by differences in ability, effort, and outside options, estimates for positions with a high risk of injury buttress the results. For these positions, mortality for players with longer

careers is more than double mortality for three-year players. This increased hazard ratio suggests that a greater injury toll explains the higher mortality for players with careers longer than three years, rather than variation in outside options (for example). Taken together with the linear results, these estimates improve on simple comparisons between the NFL and the general population and suggest that time spent in the NFL does increase mortality for at least some players.

The next section describes the NFL and my data, followed by a detailed presentation of results and concluding remarks.

II. Data

The NFL grew out of several smaller semi-professional and professional football outfits in the 1920s. League membership fluctuated through the 1940s before settling to 12 consistent teams in the 1950s. From 1947 through 1960, NFL teams played 12 regular season games and a varying number of preseason games. The rival American Football League (AFL) launched in 1960 with eight teams and a 14 game schedule, and the NFL itself added two teams from 1960 to 1961 while moving to a 14 game schedule. The AFL became competitive with the NFL fairly quickly, and the two leagues announced a merger in 1966 (consummated in 1970), keeping the NFL name. All AFL statistics from 1960 to 1969 are now compiled together with NFL statistics, and I will refer to the AFL and NFL jointly throughout the paper as simply the NFL. The ten team expansion from 1960-1961 is by far the NFL's largest permanent expansion. The NFL has added a total of ten more teams since then and increased the number of regular season games to 16 in 1978, reducing the number of preseason games to compensate. It also went through brief player strikes in 1982 (seven games canceled) and 1987 (one game canceled and replacement players used for three games).

My sample includes every NFL player born between 10/1/1937 and 10/1/1975 who played at least three years in the NFL.[1] Unless otherwise stated, all data originated from Pro Football Reference, which is a comprehensive internet database for football statistics.[2] Table 1 reports that players average about 7.4 years from their first year to their last year in the league, generally entering between ages 22 and 24. This number is slightly lower for smaller, faster players (non-lineman) at 7.1 years and higher for bigger players (lineman) at 7.8 years. Many players do not play every game per season, due to injuries or coaching decisions. Players average 88.3 games over a career, which is equivalent to 5.5 sixteen game seasons or about 12 games per year.

[1] I calculate years in the league as (last year played – first year played + 1). My sample will therefore include some players who participated in less than three seasons due to gaps in their tenure.
[2] The Pro Football Reference database is available at http://www.pro-football-reference.com.

NFL players are large. Average BMI in my sample is 29.4, while the average for the U.S. adult male population increased from about 25 in 1960 to 28 in 2000 (Ogden et al., 2004).[3] A BMI over 30 is classified as obese, and, as shown in Figure 1, average BMI for more recent players is well over 30.[4] It is important to note, however, that BMI does not account for body fat percentage or muscle mass. During their careers, NFL players are probably healthier than the average BMI-matched U.S. male or even the average U.S. male. Still, I will control for BMI in all regressions, since it is an important risk factor for many causes of death and no more sophisticated health measures are available.

I gain an additional control variable from the NFL's annual amateur draft. Over 80 percent of my sample was drafted into the NFL (the others signed contracts in the open market after the draft). During the draft, teams take turns selecting one college football player at a time. Teams have exclusive rights for one year to negotiate contracts with all of their selected players, and new players are not allowed to sign a contract with any team before the draft. Therefore, teams generally choose the best prospects first, which makes each player's selection number in the draft order a proxy for (perceived) ability. To account for undrafted players, I assign them the highest selection number plus one and include a dummy variable equal to one for undrafted players in all regressions. To account for years where the AFL held a separate draft, I take the lower selection number from the two drafts (many players were selected in both drafts) and include a dummy variable equal to one for players selected higher in the AFL draft.[5] Figure 2 shows that players drafted sooner (again taking the lower draft number when needed) have longer careers. This relationship confirms that draft number is a rough proxy for ability.

Mortality rates for my sample and subgroups are between 5 and 10 percent (last row, Table 1). I used death dates listed online at Pro Football Reference and Oldest Living Pro Football Players to determine death.[6] I cross-referenced these two databases and checked all discrepancies against obituaries and death records available online. I have also updated the first five cohorts (1937-1941) of my sample with matches from the Social Security Death Master File (SSDMF), searching on last name and month of birth and investigating close matches via web search using place of birth and any other available factors to verify identity. The SSDMF contained three players born in 1937 and 1938 not

[3] Throughout the paper, BMI is calculated as (Weight in pounds / Height in inches^2) × 703. Though I do not know exactly when player height and weight are measured, these values are generally measured early in players' careers.

[4] Various studies investigate obesity as a risk factor for heart-related health problems among NFL players (see, for example, Chang et al., 2009).

[5] Alternatively, I could include comprehensive dummies for status in each draft, but for Cox hazard estimation, adding this set of dummies to my preferred specifications leads to failed convergence in many cases. Different specifications for draft status in the OLS regressions have little effect on the point estimates of interest.

[6] The Oldest Living Pro Football Players database is accessible at http://www.oldestlivingprofootball.com.

marked as dead in my original sample and no additional players born in years 1939 to 1941, suggesting that my death information is complete or nearly complete.

Deceased players had slightly shorter careers, as shown in Table 2 (7.2 years played compared to 7.4 for the whole sample), and were slightly more likely to be drafted. The last row shows that about 5 percent of the sample died while still playing football or retired due to a terminal illness or non-football injury. These players are excluded from all regressions, since they would introduce direct reverse causality from mortality to career length.[7]

In line with Baron et al. (1994) and Baron et al. (2012), I find that NFL players live longer than the general population. Figure 3 displays Kaplan-Meier survival curves by age for NFL players and survival curves for the general population based on 2007 cross-sectional mortality and longitudinal mortality for the 1950 birth cohort from the Social Security Administration. The NFL mortality pattern is broadly similar to that of the U.S. male population, but NFL mortality is lower at every age. NFL players with BMIs above 30 show survival rates closer to the U.S. male population up to age 60 and higher survival rates thereafter. Since BMI in this range is positively correlated with mortality at most ages and average U.S. adult male BMI has risen from 25 to 28 over the period, it is likely that NFL players outlive their BMI-matched general population counterparts by a substantial margin. However, these comparisons do not answer whether playing football decreases mortality, since NFL players are a highly selected group.

For easier reference, Table 3 presents raw NFL mortality rates at different ages. Each row (and all future age-specific mortality calculations) excludes cohorts that have not reached the stated age threshold, since more players may die in these cohorts before the threshold passes. About 1-2 percent of each subgroup has died by age 40. Mortality is slightly higher for bigger players and increases to 7-13 percent before age 60 and 18-24 percent before age 70.

Since the long-term effects of head trauma have received substantial attention recently, I collected data on cause of death by conducting Google searches for death reports and obituaries, using individuals' full name, nickname(s), college attended, NFL teams played for, position played, place of birth and death, and other personal characteristics when available. Tables 4 and 5 list cause of death distributions for mortality at each age for the whole sample and for players with BMI over 30, respectively. For comparison, the tables list cause of death breakdowns for the general population from

[7] There are few such individuals, so it is unlikely that their exclusion biases the results substantially. Also, I can include most of these individuals in regressions that use the dummy for playing longer than three years as the measure of career length, since most played a fourth season. Including them in these regressions raises career length coefficient estimates slightly, while including them in linear specifications decreases the estimated career length coefficients slightly.

1999 to 2009, according to the Center for Disease Control.[8] Car accidents make up a relatively high share of NFL player deaths, especially before age 40 (20 percent). Heart attacks are also overrepresented among deaths before 40. Despite significant concern over recent high profile NFL suicides, NFL suicide rates are lower than general population rates, declining from 7 percent of NFL deaths before 40 to 3 percent of deaths before 70. However, deaths directly attributed to brain degenerative diseases (ALS, Parkinson's, CTE, Dementia, and Alzheimer's) make up 2 to 3 percent of NFL deaths at all ages, while these causes barely register in the general population. Unfortunately, I could not obtain cause of death for about 25 percent of deaths before ages 60, 65, and 70. Many of these missing causes are reported as "natural causes" and likely explain some heart and cancer death discrepancies compared to the general population at older ages. Missing data issues aside, these differences may not reflect causal effects of playing in the NFL due to possible selection biases and differences in accuracy of diagnosis.

The next section presents OLS and Cox proportional hazard regression estimates exploring the relationship between NFL career length and mortality/cause of death. To help facilitate interpretation of these results, I will present effects separately for positions with relatively high and low injury propensities. If a positive estimated relationship between career length and mortality is causal, then it should be larger for positions at higher risk of injury. Table 6 reports position-specific injury rates from 2004 to 2009 from the NFL Injury Surveillance System (summarized in Edgeworth Economics, 2010). These data include all injuries noted on teams' weekly injury reports as well as some injuries prior to the season. Fast moving, frequently tackled offensive players (running backs, wide receivers, and tight ends) are injured most often, accruing about 1.5 injuries per player per season. These players also have the highest concussion rates (about 0.1 per season), along with fast-moving defensive players (defensive backs) and quarterbacks.[9] Larger, slow-moving players (offensive line, defensive line, and linebackers) suffer only 0.04 to 0.08 head injuries per season, though defensive linemen have a high overall injury rate (about 1.5 per season).

[8] I obtained these data from the WONDER system, accessible at http://wonder.cdc.gov/mcd.html.

[9] Serious injuries may include some head injuries. Also, head injuries are generally under-diagnosed (Guskiewicz et al., 2007). They may be reported more reliably for quarterbacks since hits to the quarterback's head are highly visible. The study does not report injury rates for kickers. Kickers generally do not engage in the contact portion of the game; anecdotal evidence suggests that they have a very low injury rate and an even lower severe/head injury rate compared to other positions.

III. Results

A. Linear Career Length Specifications

I first estimate a linear relationship between career length and mortality. While these estimates may be biased by career-shortening injuries that also increase mortality, they provide a good starting point for comparison. Table 7 presents Cox proportional mortality hazard regressions according to the following constant-proportion specification:

$$h(t \mid X_i, C_i, s_i) = h_0(t \mid s_i) \exp(X_i' \beta_1 + C_i \beta_2),$$

where s_i is the stratum for individual i (defined, for example, by birth cohort), h_0 is the baseline hazard function for stratum s_i, X_i is a vector of personal characteristics (for example, BMI, height, draft status), C_i is a measure of career length, $h(t \mid X_i, C_i, s_i)$ is the hazard function for a given X_i, C_i, and s_i, and hence $\exp(\beta_2)$, averaged across all strata, is the hazard ratio of interest.[10] The first and third rows ("Years Played") set C_i equal to the last year played minus the first year played, plus one, for player i. The second and third rows ("Season Equivalents") set C_i equal to games played divided by 16. Panel A controls for demographics only (height, BMI, and birth cohort), while Panel B adds in controls related to the NFL (NFL entry cohort, draft status, and position). The column headings define the sample for analysis, and the table lists hazard ratios with 95 percent confidence intervals in square brackets.

There is little change in the mortality hazard for a one unit increase in career length, measured by years played or season equivalents. Hazard ratios for all specifications and samples are between 96 percent and 102 percent of baseline. The 95 percent confidence intervals for the full sample rule out any effect smaller than a 4 percent absolute change in mortality. The standard deviation for years played is about 3.5; therefore, these estimates are precise enough to rule out a 14 percent mortality change for a one standard deviation shift in career length.

[10] I stratify by birth cohort, NFL entry cohort, and position played rather than control for these covariates for two reasons: (1) stratifying improves optimization and precision, since the Cox proportional hazard model does not actually estimate the hazard function for each stratum (the hazard function can take any form), and (2) I am not interested in the estimated hazard ratios for these variables. Controlling for polynomials in birth cohort and NFL entry cohort instead of stratifying yields similar career length hazard ratios. I also collected racial percentages by common last names from the Census Bureau, which matched to about 75 percent of the sample. Estimating the fraction of black players in the NFL in each year, I calculated the probability that each player is black, given their last name. Controlling for this probability in the regression reduces sample size since the match was incomplete and does not meaningfully change most point estimates.

OLS regressions estimating mortality differences at various ages give similar results. Table 8 presents these estimates using the following OLS specification:

$$D(A)_i = \alpha + X_i^{'}\Upsilon_1 + C_I\Upsilon_2 + \varepsilon_i$$

where $D(A)_i$ is a dummy equal to one if player i died before age A, and X_i and C_i are defined as above. The sample excludes individuals who could not have reached age A by October 1, 2012, and all coefficients in this and later OLS tables are reported in percentage point units. Estimates for mortality differences by career length at ages 50, 60, 65, and 70 are not statistically significant and give a similar level of precision.[11] However, players with longer careers have measurably lower mortality at age 40. For every additional year played, the probability of death before age 40 is about 0.12 percentage points lower (significant at the 1 percent level). This difference is even bigger for high injury risk positions (about 0.15 percentage points, or about 7 percent of the mortality rate), which is consistent with the hypothesis that injuries shorten careers and increase mortality.[12] A longer NFL career may also keep high-BMI players fit and help all players avoid accidental and drug or alcohol related deaths. The current estimates do not distinguish between these possibilities or allow me to attribute meaning to the insignificant estimates for older age mortality. Some players with short careers may have suffered severe injuries that increased their mortality risk at all ages, and some players who died before age 40 may have had fitness or substance abuse problems that caused both their retirement and early death. To learn more, I examine mortality differences for players with three year careers versus careers longer than three years.

B. Three-Year Threshold Specifications

Players who retire after three years may retire due to injury, but they have not had much time to accumulate a long, mortality-increasing injury history. The results for this specification are quite different: players with careers longer than three years have higher mortality than three-year players. Tables 9 and 10 repeat the Cox hazard and OLS analyses in Tables 7 and 8, respectively, replacing linear measures of career length with dummies for playing more than three years. Table 9 shows that, after controlling for personal characteristics, NFL entry characteristics, and position, players who last longer

[11] For example, whole-sample mortality at age 50 is about 3.5 percent. The estimated standard errors for age 50 mortality differences by years played rule out any change less than 0.15 percentage points. The standard deviation of years played is about 3.5 years, so I can rule out a mortality difference of about 0.525 percentage points for a one standard deviation change. This difference is 15 percent of observed age 50 mortality.

[12] Significant OLS estimates at just one age suggest that mortality differences by career length may violate the constant proportions assumption made for Cox hazard estimation. However, interactions between age and career length are not statistically significant when added to the Cox models.

than three years have mortality rates over 40 percent higher than three-year players (significant at the 5 percent level). Within positions with a high risk of injury, mortality is over twice as high for those with careers over three years compared with three-year players. Although sample size shrinks at older ages, Kaplan-Meier survival curves presented in Figures 4 and 5 suggest that the mortality hazard ratios for the whole sample and for high-injury positions are similar across all ages. The mortality point estimates in Table 10 are also consistent with these findings, though they are only statistically significant for age 50 and age 60 mortality within positions with a high risk of injury. These results suggest that NFL injuries increase mortality and that career-shortening injuries are biasing the linear estimates downwards.

This analysis ignores extant selection effects, however. Although draft selection number is not a perfect proxy for ability, the average selection number for three-year players is about 145, while the average selection number for players with more than three years' experience is 115 (lower numbers imply earlier selection and therefore higher ability). Ability deficiencies for three-year players not captured by the draft could push mortality estimates lower. More worrying, these players may also have better outside options that induce early retirement. This omitted variable could explain the mortality increase for players with careers longer than three years. While these factors prevent clean interpretation of the results, the larger point estimates for high-injury-risk positions suggest that injuries from time spent in the NFL cause at least some increase in mortality.

C. Cause of Death and Concussions

Recent research suggests that repeated concussions may increase the probability of death due to advanced CTE, though these studies are not yet conclusive due to small samples and limited use of control populations (see, for example, Stern et al., 2011). If time in the NFL actually increases mortality, head injuries are one possible channel for the effect. CTE causes erratic behavior, irritability, depression, memory loss, and, eventually, a reduction in muscle control that mimics other diseases such as Parkinson's, ALS, and Alzheimer's, leading to misdiagnosis (McKee et al., 2009). As with other degenerative brain diseases, CTE itself may cause death, but CTE also increases risk factors for many other causes of death. To test for this channel, I analyze whether death rates for causes tied closest to CTE are higher for players with more than three years' experience.

Specifically, I examine whether death due to degenerative brain diseases or suicide is more common for individuals with careers longer than three years. Though CTE linkages for other causes are weaker, I also address whether death due to alcohol and drug abuse is more common for these individuals. Finally, I repeat the analysis by position-specific concussion risk. Tables 11 through 13

present the relationship between career length and specific causes of death, controlling for personal characteristics, position, and NFL entry characteristics. These tables list coefficients in percentage point terms from separate OLS regressions for each cause of death, setting the dependent variable equal to one for the cause of interest and equal to zero for survivors and for all other causes of death.[13] The top row duplicates the results for death by any cause from the corresponding column of Table 10.

For the whole sample, mortality at age 40 due to degenerative brain diseases or suicide is about 0.09 percentage points higher for players with careers longer than three years versus three-year players (significant at the 5 percent level). While this difference seems small, overall mortality at age 40 due to these causes is only about 0.14 percent. Similarly, the difference at age 50 is about 0.16 percentage points, against an overall mortality rate of 0.25. Mentally-related mortality rates are not significantly different between groups at age 60 or 65, and though statistically significant at age 70, the difference is implausibly large. Differences for mortality rates including drug and alcohol abuse are a similarly large percentage of the overall mortality rate at ages 40 and 50.

Although these results are consistent with the claim that longer careers lead to more concussions, which lead to brain degeneration, there are three caveats that prevent this interpretation. First, cause of death is more likely to be missing for players with shorter careers, inflating estimates for all other causes of death. This is particularly evident at older ages in Table 11. Large, offsetting coefficients for the missing category balanced against the cardiovascular, cancer, transport-accident, and mentally-related mortality categories probably reflect data limitations for players with short careers rather than any real difference. Second, most mentally-related deaths under age 50 in the sample are due to suicide, which may be driven by depression or other life factors unrelated to concussions.[14] Third, Tables 12 and 13 show that differences in mentally-related mortality rates are biggest for positions with the lowest risk of concussion. Given these challenges, I can draw no conclusion concerning what injuries generate the mortality increase observed for NFL players with careers longer than three years.

[13] I present OLS results only for this section, since the Cox hazard models are highly erratic and often fail to converge with full controls included for these low-mean dependent variables.

[14] One recent high profile case involved Junior Seau, a former star in the NFL. Seau, who is included in this study, committed suicide in May, 2012, at age 43 by shooting himself in the chest to ensure that researchers could study his brain. Seau may or may not have had CTE. Autopsy results found no surface evidence of CTE in Seau's brain, although early-stage CTE cannot be diagnosed without more in depth analysis. The National Institutes of Health is now examining his brain tissue (Conboy, 2012).

IV. Conclusions

Popular opinion holds that playing in the NFL increases mortality risk greatly, lowering life expectancy into the 50s (see, for example, Will, 2012). This view is greatly exaggerated; a recent NIOSH study (Baron et al., 2012) shows that NFL players actually live longer than the general population. However, NFL players are a highly selected group of athletically talented individuals, and a trove of survey and clinical work suggests that quality of life for NFL retirees is poor due to high rates of arthritis and depression and dementia (linked to concussions). In this context, I analyze whether NFL player career length increases mortality in retirement for players born between 10/1/1937 and 10/1/1975 with at least three years of experience. This approach eliminates many omitted variables that plague earlier studies comparing NFL players to the general population. However, barriers to causal inference remain. Career-shortening injuries, ability/heredity, perseverance, and differing outside options may all bias estimates of the effect of career length on mortality, primarily downwards.

Naive analysis employing a linear measure of career length shows that longer careers are associated with slightly lower age 40 mortality, while career length is unrelated to mortality above age 40. This result suggests that the true effect could be positive. For comparison, Major League Baseball career length is strongly negatively correlated with mortality at all ages, likely due to income effects and the same negative biases relevant in football (Abel and Kruger, 2006, Saint Onge, Rogers, and Krueger, 2008). While the NFL's selection process and financial rewards may differ from Major League Baseball's, baseball has far fewer career-shortening and mortality-increasing injuries. These injuries bias my NFL estimates downwards, yet I still estimate a less negative relationship in the NFL than the relationship reported for Major League Baseball.

To reduce injury bias and narrow in on the causal mortality effect of playing in the NFL, I compare players with more than three years of NFL experience to players with just three years of experience. I claim that players who retire after just three years have shorter injury histories that have less effect on mortality in retirement than injury histories for later retirees.[15] Players who persisted for longer than three years have 40 percent higher mortality than three-year players, across all ages. This increase is driven in large part by a doubling of the mortality rate for positions with a high risk of injury.

Although variation in players' outside options may explain some of these differences, these estimates provides the most direct evidence to date that time spent in the NFL increases mortality in retirement. I am currently assembling injury data for recent players to help understand the relationship between injuries and retirement. I also plan to use playoff-game participation as an instrument for

[15] I am currently collecting injury data for recent NFL players to test this claim.

career exposure and collect data for players with one and two year careers to investigate even earlier retirement margins. My current estimates suggest that accumulated injuries reduce career length and increase mortality.

References

Abel, E.L., and M.L. Kruger. 2006. "The Healthy Worker Effect in Major League Baseball," Research in Sports Medicine 14(1): 83-87.

Baron, Sherry L., and R. Rinsky. 1994. "Health Hazard Evaluation Report, National Football League Players Mortality Study," Report No. HETA 88-085. Atlanta, GA: Centers for Disease Control and Prevention, National Institute for Occupational Safety and Health.

Baron, Sherry L., Misty J. Hein, Everett Lehman, and Christine M. Gersic. 2012. "Body Mass Index, Playing Position, Race, and the Cardiovascular Mortality of Retired Professional Football Players," The American Journal of Cardiology 109(6): 889-896.

Carpenter, L.M. 1987. "Some Observations on the Healthy Worker Effect," British Journal of Industrial Medicine 44: 289-291.

Chang, Alice Y., Shannon J. FitzGerald, John Cannaday, Song Zhang, Amit Patel, M. Dean Palmer, Gautham P. Reddy, Karen G. Ordovas, Arthur E. Stillman, Warren Janowitz, Nina B. Radford, Arthur J. Roberts, and Benjamin D. Levine. 2009. "Cardiovascular Risk Factors and Coronary Atherosclerosis in Retired National Football League Players," The American Journal of Cardiology 104(6): 805-811.

Conboy, Sean. 2012. "Football Did Not Kill Junior Seau – Unless it Did," Wired. http://www.wired.com/playbook/2012/08/junior-seau-autopsy/.

Edgeworth Economics. 2010. "Dangers of the Game: Injuries in the NFL," Analysis for the NFLPA.

Golightly, Yvonne M., Stephen W. Marshall, Leigh F. Callahan, and Kevin Guskiewicz. 2009. "Early-Onset Arthritis in Retirement," Journal of Physical Activity and Health 6: 638-643.

Guskiewicz, Kevin M., Stephen W. Marshall, Julian Bailes, Michael McCrea, Robert C. Cantu, C. Randolph, and B.D. Jordan. 2005. "Association between Recurrent Concussion and Late-Life Cognitive Impairment in Retired Professional Football Players," Neurosurgery 57(4): 719-726.

Guskiewicz, Kevin M., Stephen W. Marshall, Julian Bailes, Michael McCrea, Herndon P. Harding, Jr., Amy Matthews, Johna Register Mihalik, and Robert C. Cantu. 2007. "Recurrent Concussion and Risk of Depression in Retired Professional Football Players," Medicine and Science in Sports and Exercise 39(6): 903-909.

Lehman, Everett J., Misty J. Hein, Sherry L. Baron, and Christine M. Gersic. 2012. "Neurodegenerative Causes of Death among Retired National Football League Players," Neurology 79: 1-5.

McKee, Ann C., Robert C. Cantu, Christopher J. Nowinski, E. Tessa Hedley-Whyte, Brandon E. Gavett, Andrew E. Budson, Veronica E. Santini, Hyo-Soon Lee, Caroline A. Kubilus, and Robert A. Stern. 2009. "Chronic Traumatic Encephalopathy in Athletes: Progressive Tauopathy following Repetitive Head Injury," Journal of Neuropathy and Experimental Neurology 68(7): 709-735.

McMichael, A.J. 1976. "Standardized Mortality Ratios and the 'Healthy Worker Effect': Scratching Beneath the Surface," Journal of Occupational Medicine 18(3): 165-168.

McMichael, A.J., R. Spirtas, and L.L. Kupper. 1974. "An Epidemiological Study of Mortality within a Cohort of Rubber Workers, 1964-1972," Journal of Occupational Medicine 16(7): 458-464.

Ogden, Cynthia L., Cheryl D. Fryar, Margaret D. Carroll, and Katherine M. Flegal. 2004. "Mean Body Weight, Height, and Body Mass Index, United States 1960-2000," Advance Data from Vital and Health Statistics 347: 1-18.

Saint Onge, Jarron M., Richard G. Rogers, and Patrick M. Krueger. 2008. "Major League Baseball Players' Life Expectancies," Social Science Quarterly 89(3): 817-830.

Stern, Robert A., David O. Riley, Daniel H. Daneshvar, Christopher J. Nowinski, Robert C. Cantu, Ann C. McKee. 2011. "Long-term Consequences of Repetitive Brain Trauma: Chronic Traumatic Encephalopathy," Physical Medicine and Rehabilitation 3(10S2): S460-S467.

Will, George F. 2012. "Football's Growing Killer Problem," New York Post, http://www.nypost.com/p/news/opinion/opedcolumnists/football_growing_killer_problem_1fnQKvhkFse7V6x4tG9iwN.

Table 1. NFL Player Characteristics

	All	Non-Lineman	Lineman	BMI > 30
Years played	7.4	7.1	7.8	7.7
	(3.5)	(3.3)	(3.5)	(3.5)
Games played	88.3	83.5	95.2	94.8
	(53.4)	(49.9)	(55.2)	(55.0)
Season equivalents*	5.5	5.2	6.0	5.9
	(3.3)	(3.1)	(3.4)	(3.4)
Career starting year	1981.1	1981.2	1980.8	1983.6
	(11.1)	(11.0)	(11.5)	(11.2)
BMI	29.4	27.8	33.2	33.0
	(3.6)	(2.4)	(2.9)	(2.5)
Drafted	0.81	0.81	0.85	0.82
	(0.39)	(0.39)	(0.36)	(0.38)
Dead	0.07	0.06	0.10	0.08
	(0.26)	(0.24)	(0.30)	(0.28)
N	7,484	4,884	2,339	3,002

*Games played divided by 16

Note: Sample includes players with at least three years experience born between 10/1/1937 and 10/1/1975. Standard deviations are in parentheses.

Table 2. Deceased NFL Player Characteristics

	All	Non-Lineman	Lineman	BMI > 30
Years played	7.2	6.9	7.6	7.8
Games played	86.0	79.7	93.6	97.0
Season equivalents*	5.4	5.0	5.8	6.1
Career starting year	1972	1971	1972	1973
BMI	29.7	27.7	32.4	32.5
Drafted	0.85	0.86	0.86	0.86
Death ended career	0.05	0.06	0.04	0.06
N	548	302	233	251

*Games played divided by 16

Note: Sample includes players with at least three years experience born between 10/1/1937 and 10/1/1975.

Table 3. Percent Mortality by Age

	All	Non-Lineman	Lineman	BMI>30
Dead by 40	1.5	1.2	2.1	2.0
N	6,690	4,382	2,070	2,545
Dead by 50	3.5	3.2	4.4	4.8
N	4,565	2,972	1,422	1,475
Dead by 60	8.7	7.4	11.3	12.6
N	2,392	1,509	806	740
Dead by 65	12.3	11.5	13.6	15.5
N	1,565	974	545	511
Dead by 70	19.7	18.2	22.5	23.8
N	753	467	267	256

Note: Samples include players with at least three years experience born between 10/1/1937 and 10/1/1975 who (would have) reached the specified age by 10/1/2012.

Table 4. Cause of Death Distributions by Age of Death

	Age < 40		Age < 50		Age < 60		Age < 65		Age < 70	
	NFL	Gen Pop	NFL	Gen Pop	NFL	Gen Pop	NFL	Gen Pop	NFL	Gen Pop
Cardiovascular	0.25	0.14	0.28	0.25	0.29	0.32	0.29	0.32	0.28	0.33
Cancer	0.14	0.09	0.16	0.17	0.16	0.29	0.18	0.31	0.18	0.33
Degenerative*	0.02	0.00	0.02	0.00	0.02	0.00	0.02	0.00	0.03	0.01
Other Internal	0.01	0.22	0.03	0.25	0.04	0.24	0.04	0.23	0.05	0.23
Transport Accident	0.20	0.13	0.12	0.11	0.09	0.06	0.08	0.04	0.07	0.04
Drugs/Alcohol	0.05	0.14	0.04	0.07	0.03	0.03	0.03	0.02	0.03	0.02
Suicide	0.07	0.12	0.05	0.07	0.04	0.03	0.03	0.03	0.03	0.02
Other External	0.19	0.15	0.12	0.07	0.09	0.03	0.08	0.03	0.07	0.02
Missing	0.08		0.16		0.26		0.26		0.27	
Total	**1.00**	**1.00**	**1.01**	**1.00**	**1.02**	**1.00**	**1.02**	**1.00**	**1.02**	**1.00**
N	106		226		380		447		517	

*ALS, Parkinson's, Chronic Traumatic Encephalopathy, Dementia, Alzheimer's

Note: The NFL population includes players with at least three years experience born between 10/1/1937 and 10/1/1975. "Total" may be greater than one due to cases with multiple causes of death. General population death rates (from the Center for Disease Control) reflect all deaths over age 30 and under the indicated age.

Table 5. Cause of Death Distributions by Age of Death (BMI > 30)

	Age < 40		Age < 50		Age < 60		Age < 65		Age < 70	
	NFL	Gen Pop	NFL	Gen Pop	NFL	Gen Pop	NFL	Gen Pop	NFL	Gen Pop
Cardiovascular	0.34	0.14	0.39	0.25	0.35	0.32	0.35	0.32	0.33	0.33
Cancer	0.12	0.09	0.14	0.17	0.15	0.29	0.15	0.31	0.17	0.33
Degenerative*	0.03	0.00	0.03	0.00	0.02	0.00	0.01	0.00	0.03	0.01
Other Internal	0.00	0.22	0.02	0.25	0.03	0.24	0.03	0.23	0.05	0.23
Transport Accident	0.22	0.13	0.13	0.11	0.11	0.06	0.11	0.04	0.09	0.04
Drugs/Alcohol	0.03	0.14	0.03	0.07	0.03	0.03	0.02	0.02	0.02	0.02
Suicide	0.07	0.12	0.06	0.07	0.04	0.03	0.03	0.03	0.03	0.02
Other External	0.12	0.15	0.10	0.07	0.07	0.03	0.06	0.03	0.06	0.02
Missing	0.05		0.12		0.23		0.23		0.23	
Total	**1.00**	**1.00**	**1.02**	**1.00**	**1.02**	**1.00**	**1.01**	**1.00**	**1.01**	**1.00**
N	58		119		188		203		237	

*ALS, Parkinson's, Chronic Traumatic Encephalopathy, Dementia, Alzheimer's

Note: The NFL population includes players with at least three years experience born between 10/1/1937 and 10/1/1975. "Total" may be greater than one due to cases with multiple causes of death. General population death rates (from the Center for Disease Control) reflect all deaths over age 30 and under the indicated age.

Table 6. Injuries per Player per Season by Position (2004-2009)

Position	Any	Severe	Head
Quarterback	0.86	0.20	0.11
Offensive Line	1.16	0.28	0.04
Linebacker	1.25	0.26	0.08
Defensive Back	1.37	0.29	0.10
Running Back	1.45	0.29	0.11
Wide Receiver	1.47	0.26	0.10
Defensive Line	1.47	0.29	0.04
Tight End	1.52	0.30	0.11

Note: Statistics from the NFL Injury Surveillance System as reported in Edgeworth Economics (2010).

Table 7. Career Length and Cox Mortality Hazard Ratios

	All	High Injury Position	Low Injury Position	High Concussion Position	Low Concussion Position
		Panel A. Demographic Controls			
Years Played	1.00	1.01	1.00	0.98	1.01
	[0.97 - 1.02]	[0.98 - 1.05]	[0.96 - 1.03]	[0.94 - 1.02]	[0.97 - 1.04]
Season Equivalents	1.00	1.02	0.99	0.97	1.01
	[0.97 - 1.03]	[0.99 - 1.06]	[0.95 - 1.03]	[0.93 - 1.01]	[0.98 - 1.05]
		Panel B. Full Controls			
Years Played	0.99	1.02	0.97	0.98	1.00
	[0.96 - 1.02]	[0.97 - 1.06]	[0.93 - 1.02]	[0.94 - 1.03]	[0.96 - 1.04]
Season Equivalents	0.99	1.02	0.97	0.97	1.01
	[0.96 - 1.02]	[0.97 - 1.07]	[0.93 - 1.02]	[0.92 - 1.03]	[0.97 - 1.05]
N	7,428	3,217	3,950	3,803	3,364

Note: The table reports mortality hazard ratios for Cox proportional hazard models with constant effects by age, stratified by birth cohort in panel A and stratified by birth cohort, NFL entry cohort, and position in panel B. The row labels denote the career length measure used and the column headings denote the group analyzed in each regression. Demographic controls (panel A) include BMI, BMI squared, height, and height squared. Panel B adds draft status controls, as described in the Data section of the paper. High injury positions are tight ends, defensive lineman, wide receivers, and running backs; high concussion positions are quarterbacks, defensive backs, running backs, wide receivers, and tight ends. Low injury and low concussion positions are the respective complements, including kickers. I derive 95 percent confidence intervals (in square brackets) from robust standard errors.

Table 8. Career Length and Percent Mortality (OLS)

	All		High Injury Position		Low Injury Position	
	Years Played	Season Equivalents	Years Played	Season Equivalents	Years Played	Season Equivalents
Dead by 40	-0.116***	-0.118***	-0.146***	-0.144***	-0.098**	-0.103**
	(0.032)	(0.033)	(0.053)	(0.055)	(0.044)	(0.046)
N	6,665	6,665	2,884	2,884	3,543	3,543
Dead by 50	-0.109	-0.091	-0.131	-0.093	-0.088	-0.080
	(0.075)	(0.079)	(0.123)	(0.121)	(0.105)	(0.115)
N	4,549	4,549	1,951	1,951	2,427	2,427
Dead by 60	-0.158	-0.118	0.109	0.128	-0.281	-0.202
	(0.168)	(0.183)	(0.295)	(0.313)	(0.214)	(0.238)
N	2,383	2,383	1,042	1,042	1,264	1,264
Dead by 65	-0.170	-0.233	-0.186	-0.132	-0.194	-0.316
	(0.243)	(0.269)	(0.406)	(0.444)	(0.305)	(0.344)
N	1,558	1,558	675	675	837	837
Dead by 70	-0.186	-0.374	-0.544	-0.669	0.043	-0.187
	(0.435)	(0.478)	(0.822)	(0.902)	(0.512)	(0.563)
N	750	750	312	312	419	419

Note: OLS regressions include position and NFL entry year fixed effects, a third degree polynomial in date of birth, baseline BMI, BMI squared, height, height squared, and draft status controls, as described in the Data section of the paper. High injury positions are tight ends, defensive lineman, wide receivers, and running backs; high concussion positions are quarterbacks, defensive backs, running backs, wide receivers, and tight ends. Low injury and low concussion positions are the respective complements, including kickers. Coefficients are measured in percentage points. Robust standard errors are in parentheses.

Table 9. Career Length and Cox Mortality Hazard Ratios

	All	High Injury Position	Low Injury Position	High Concussion Position	Low Concussion Position
		Panel A. Demographic Controls			
Years Played > 3	1.28*	1.61**	1.08	1.63**	1.02
	[0.96 - 1.70]	[1.06 - 2.44]	[0.71 - 1.63]	[1.04 - 2.56]	[0.70 - 1.50]
		Panel B. Full Controls			
Years Played > 3	1.42**	2.24***	0.93	1.83**	1.19
	[1.02 - 1.98]	[1.38 - 3.66]	[0.59 - 1.47]	[1.09 - 3.06]	[0.76 - 1.88]
N	7,428	3,217	3,950	3,803	3,364

Note: The table reports mortality hazard ratios for Cox proportional hazard models with constant effects by age, stratified by birth cohort in panel A and stratified by birth cohort, NFL entry cohort, and position in panel B. The row labels denote the career length measure used and the column headings denote the group analyzed in each regression. Demographic controls (panel A) include BMI, BMI squared, height, and height squared. Panel B adds draft status controls, as described in the Data section of the paper. High injury positions are tight ends, defensive lineman, wide receivers, and running backs; high concussion positions are quarterbacks, defensive backs, running backs, wide receivers, and tight ends. Low injury and low concussion positions are the respective complements, including kickers. I derive 95 percent confidence intervals (in square brackets) from robust standard errors.

Table 10. More than Three Years Played and Percent Mortality (OLS)

	All	High Injury Position	Low Injury Position
Dead by 40	0.109	0.541	-0.282
	(0.353)	(0.488)	(0.546)
N	6,665	2,884	3,543
Dead by 50	0.958	1.985**	0.309
	(0.694)	(0.869)	(1.053)
N	4,549	1,951	2,427
Dead by 60	2.164	4.033*	0.071
	(1.528)	(2.266)	(2.194)
N	2,383	1,042	1,264
Dead by 65	0.389	4.317	-1.907
	(2.507)	(3.688)	(3.534)
N	1,558	675	837
Dead by 70	1.052	3.788	0.732
	(4.616)	(7.203)	(6.512)
N	750	312	419

Note: OLS regressions include position and NFL entry year fixed effects, a third degree polynomial in date of birth, baseline BMI, BMI squared, height, height squared, and draft status controls, as described in the Data section of the paper. High injury positions are tight ends, defensive lineman, wide receivers, and running backs; high concussion positions are quarterbacks, defensive backs, running backs, wide receivers, and tight ends. Low injury and low concussion positions are the respective complements, including kickers. Coefficients are measured in percentage points. Robust standard errors are in parentheses.

Table 11. More than Three Years Played and Percent Mortality due to Selected Causes of Death

	Age < 40	Age < 50	Age < 60	Age < 65	Age < 70
Any	0.109	0.958	2.164	0.389	1.052
	(0.353)	(0.694)	(1.528)	(2.507)	(4.616)
Cardiovascular	0.174	0.504*	1.708***	1.614*	2.635
	(0.134)	(0.295)	(0.438)	(0.859)	(1.657)
Cancer	0.021	0.321	0.901	1.872**	3.811***
	(0.133)	(0.303)	(0.666)	(0.754)	(1.120)
Transport Accident	-0.224	-0.183	0.488***	0.569**	0.394
	(0.198)	(0.259)	(0.183)	(0.244)	(0.319)
Other External	0.114	-0.005	-0.618	-0.631	-0.746
	(0.132)	(0.267)	(0.566)	(0.787)	(1.221)
Missing	-0.115	-0.019	-0.484	-3.792*	-7.307*
	(0.175)	(0.420)	(1.149)	(2.089)	(4.024)
Degenerative*,	0.092**	0.156***	0.014	0.115	1.478**
Suicide	(0.042)	(0.059)	(0.300)	(0.530)	(0.628)
Degenerative*,	0.122***	0.311***	0.328	0.317	1.478**
Suicide, Drugs/Alcohol	(0.045)	(0.093)	(0.331)	(0.546)	(0.628)
N	6,665	4,549	2,383	1,558	750

*ALS, Parkinson's, Chronic Traumatic Encephalopathy, Dementia, Alzheimer's

Note: OLS regressions include position and NFL entry year fixed effects, a third degree polynomial in date of birth, baseline BMI, BMI squared, height, height squared, and draft status controls, as described in the Data section of the paper. Coefficients are measured in percentage points. Robust standard errors are in parentheses.

Table 12. More than Three Years Played and Percent Mortality due to Selected Causes of Death (High Concussion Risk)

	Age < 40	Age < 50	Age < 60	Age < 65	Age < 70
Any	-0.044	1.339*	2.755	1.270	4.418
	(0.452)	(0.777)	(1.730)	(3.191)	(5.519)
Cardiovascular	0.158*	0.444	1.113*	1.100	1.937
	(0.082)	(0.339)	(0.631)	(1.072)	(2.653)
Cancer	0.149*	0.676***	0.919	1.956	5.144***
	(0.087)	(0.237)	(0.951)	(1.258)	(1.750)
Transport Accident	-0.156	0.094	0.427*	0.602	--
	(0.222)	(0.064)	(0.258)	(0.381)	--
Other External	0.026	-0.017	-0.152	0.405	0.226
	(0.209)	(0.302)	(0.457)	(0.271)	(0.526)
Missing	-0.336	-0.241	-0.024	-3.302	-7.045
	(0.303)	(0.572)	(1.184)	(2.545)	(4.663)
Degenerative*,	0.064	0.090	-0.373	-0.368	1.302*
Suicide	(0.051)	(0.057)	(0.534)	(0.986)	(0.774)
Degenerative*,	0.074	0.304**	0.083	0.003	1.302*
Suicide, Drugs/Alcohol	(0.052)	(0.130)	(0.587)	(1.015)	(0.774)
N	3,421	2,316	1,198	772	377

*ALS, Parkinson's, Chronic Traumatic Encephalopathy, Dementia, Alzheimer's

Note: OLS regressions include position and NFL entry year fixed effects, a third degree polynomial in date of birth, baseline BMI, BMI squared, height, height squared, and draft status controls, as described in the Data section of the paper. Coefficients are measured in percentage points. Robust standard errors are in parentheses.

Table 13. More than Three Years Played and Percent Mortality due to Selected Causes of Death (Low Concussion Risk)

	Age < 40	Age < 50	Age < 60	Age < 65	Age < 70
Any	0.386	1.231	1.089	0.315	-0.026
	(0.634)	(1.299)	(2.863)	(4.098)	(8.077)
Cardiovascular	0.180	0.706	2.062***	2.986***	3.671*
	(0.334)	(0.548)	(0.599)	(0.976)	(2.043)
Cancer	-0.142	-0.004	1.268	2.301***	4.426**
	(0.305)	(0.734)	(0.964)	(0.835)	(1.978)
Transport Accident	-0.326	-0.122	0.598*	0.819*	0.922
	(0.396)	(0.450)	(0.332)	(0.477)	(0.749)
Other External	0.238*	0.031	-1.102	-1.863	-1.845
	(0.130)	(0.530)	(1.150)	(1.703)	(2.466)
Missing	0.230*	0.308	-1.544	-4.929	-7.112
	(0.135)	(0.698)	(2.297)	(3.613)	(7.166)
Degenerative*,	0.152*	0.316*	0.560**	0.764*	2.100*
Suicide	(0.091)	(0.170)	(0.278)	(0.391)	(1.141)
Degenerative*,	0.206**	0.396**	0.691**	0.764*	2.100*
Suicide, Drugs/Alcohol	(0.099)	(0.185)	(0.297)	(0.391)	(1.141)
N	3,006	2,062	1,108	740	354

*ALS, Parkinson's, Chronic Traumatic Encephalopathy, Dementia, Alzheimer's

Note: OLS regressions include position and NFL entry year fixed effects, a third degree polynomial in date of birth, baseline BMI, BMI squared, height, height squared, and draft status controls, as described in the Data section of the paper. Coefficients are measured in percentage points. Robust standard errors are in parentheses.

Figure 1. NFL Player BMI Over Time

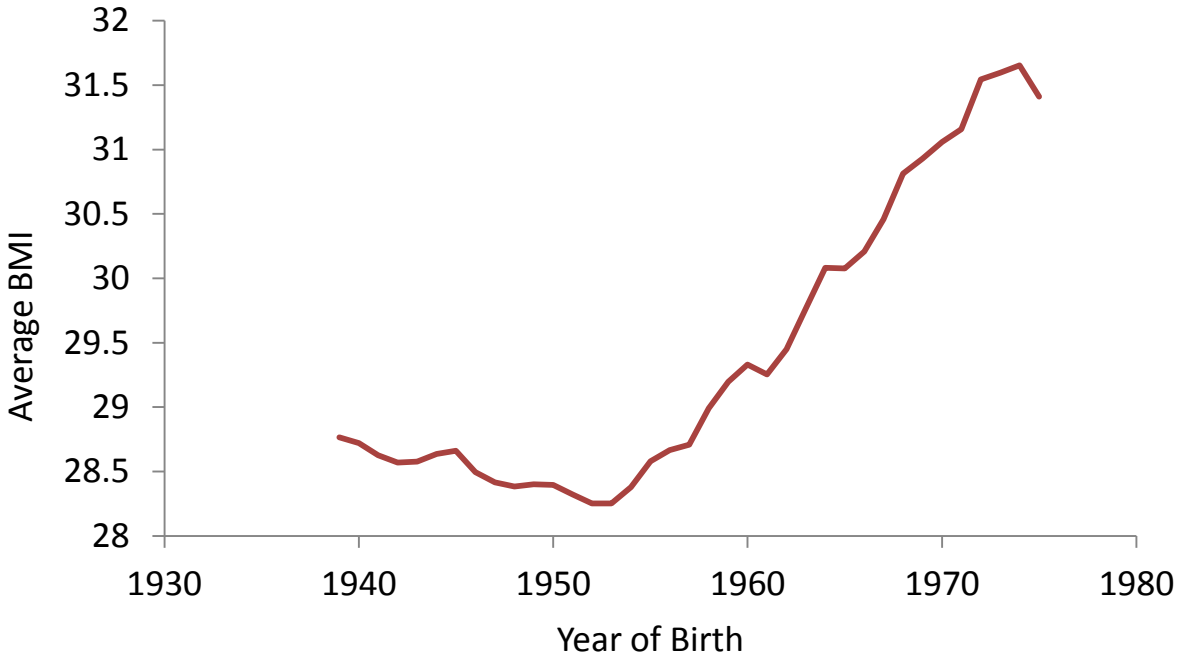

Figure 2. AFL/NFL Draft Selection Number and Years Played

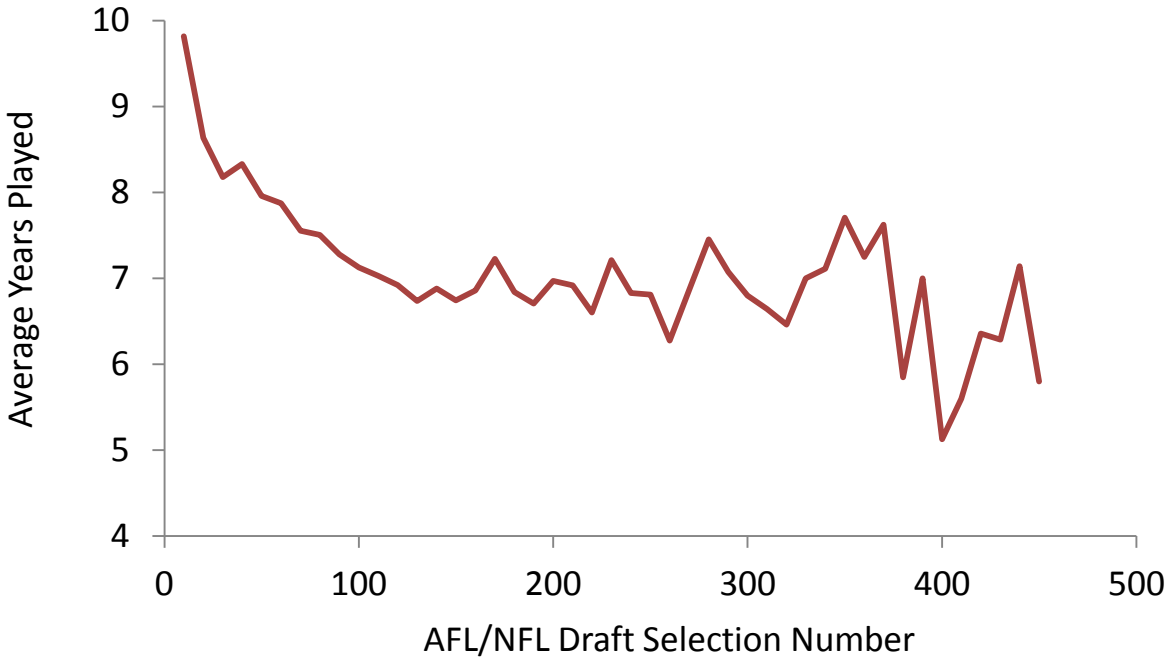

Figure 3. Kaplan-Meier Survival Curves for NFL Players and the General Population

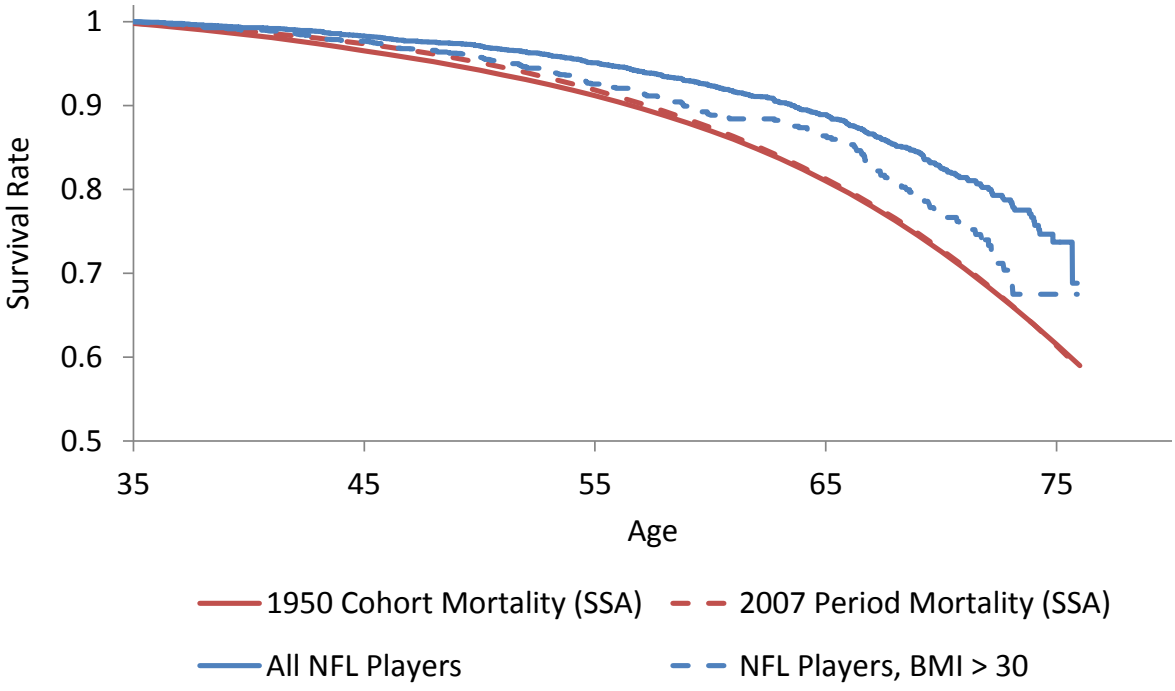

Figure 4. Kaplan-Meier Survival Curves by Career Length

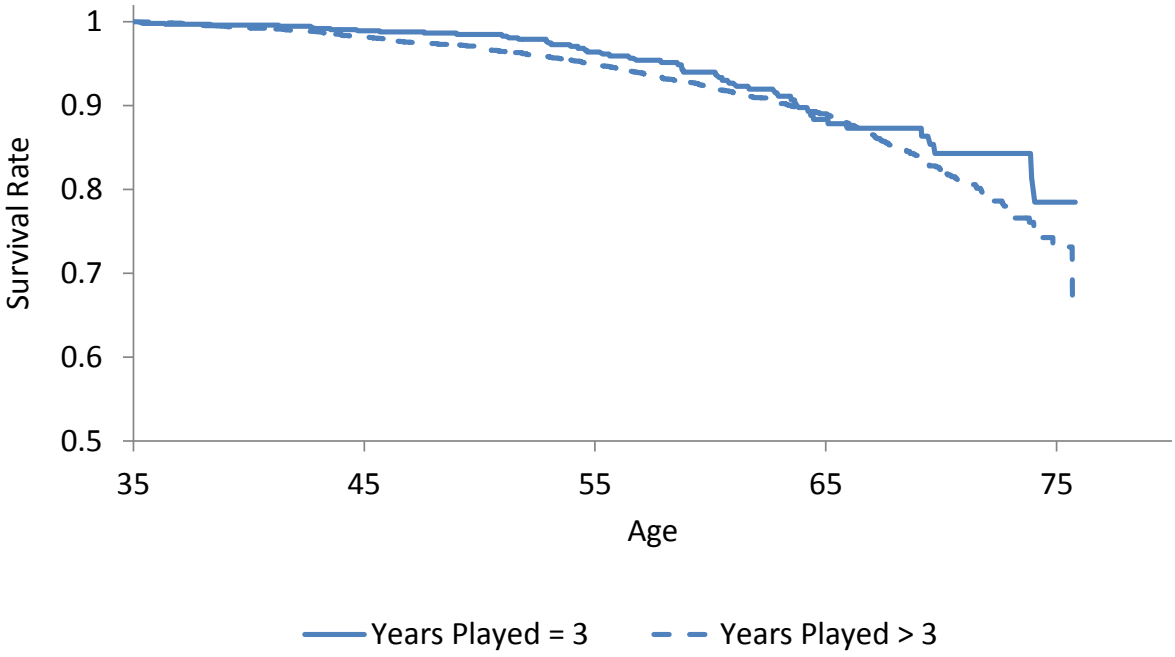
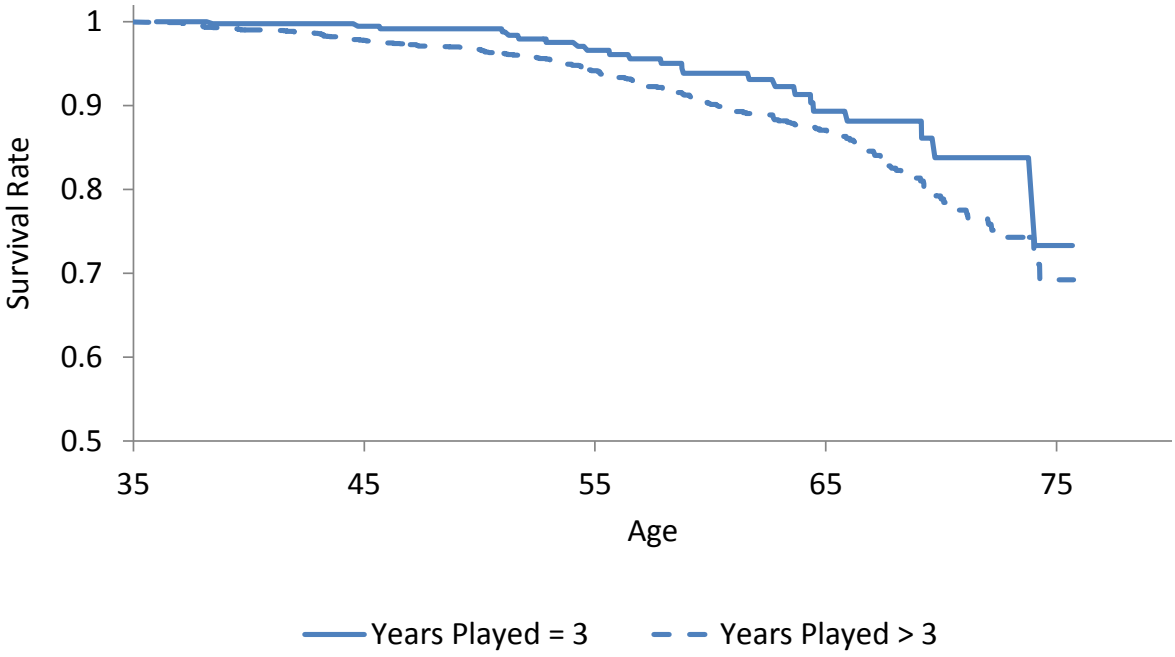
Figure 5. Kaplan-Meier Survival Curves by Career Length, High Injury Risk Positions