BRIEF REPORT

Mortality risk factors among National Football League players: An analysis using player career data [version 1; peer review: 1 approved, 1 approved with reservations]

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Abstract
In general, National Football League (NFL) players tend to live longer than the general population. However, little information exists about the long-term mortality risk in this population. Frequent, yet mild, head trauma may be associated with early mortality in this group of elite athletes. Therefore, career playing statistics can be used as a proxy for frequent head trauma. Using data from Pro Football Reference, we analyzed the association between age-at-death, position, and NFL seasons-played among 6,408 NFL players that were deceased as of July 1, 2018. The linear regression model allowing for a healthy worker effect demonstrated the best fit statistics (F-statistic = 9.95, p-value = 0.0016). The overall association of age-at-death and seasons-played is positive beginning at the 10.75 and 10.64 seasons-played point in our two models that feature seasons-played and seasons-played squared as explanatory variables. Previous research that does not account for the healthy worker effect may not adequately describe mortality risk among NFL players.

Keywords
CTE, concussions, football, gridiron football, NFL, chronic traumatic encephalopathy, sports

Open Peer Review

Invited Reviewers

1. Adam M. Finkel, University of Michigan School of Public Health, Ann Arbor, USA
2. Thomas Sadler, Western Illinois University, Macomb, USA

Any reports and responses or comments on the article can be found at the end of the article.
Introduction

Very little information exists about mortality and long-term health outcomes among National Football League (NFL) players. Elite football players tend to have a lower overall mortality rate than the general population, often attributed to routine physical activity\textsuperscript{[1,2]}. However, this occupational group cannot be directly compared to the general population\textsuperscript{[3,4]}. Several studies in small numbers of NFL players have found an association between traumatic brain injuries with depression, suicide, dementia, and chronic traumatic encephalopathy\textsuperscript{[5,6]}. There is mounting evidence that even sub-clinical head impacts, especially when they occur frequently, can also lead to these adverse health outcomes\textsuperscript{[7,8]}. However, these relationships are difficult to study systematically due to few cases, challenges with diagnostics, and long lag time from the injury to symptom onset. Yet, there exists a rich repository of data surrounding NFL career playing statistics\textsuperscript{[9]}. We hypothesize that certain player career attributes, including position-of-play and seasons-played, are likely to be strong predictors for mortality from repeated, yet mild, head trauma. Here, we study the association between mortality and NFL seasons-played, while controlling for playing position.

Methods

Data was collected from Pro Football Reference, a free online database maintained by Sports Reference LLC that includes playing statistics from every player in NFL history, over 25,000 in total, with meticulously recorded data beginning in 1922\textsuperscript{[10]}. Merged and transformed data is available from an open repository\textsuperscript{[11]}. Variables of interest include birthdate, death date, position, and seasons-played. Individuals with any missing data were eliminated, leaving 24,740 players. Of those, 6,408 (25.9\%) had died according to Pro Football Reference, as of July 1, 2018. Playing position was divided into three standard categories according to previous literature\textsuperscript{[12]}. Category 1: defensive back, quarterback, wide receiver, and kicker: 1,600 dead/8,415 players (19\%). Category 2: running back, linebacker, tight end: 1,690 dead/7,228 players (23\%). Category 3: offensive and defensive linemen: 3,118 dead/9,097 players (34\%).

Statistical analysis

Expected age-at-death was calculated from the 2017 National Vital Statistics Report\textsuperscript{[13]}. Using average years of life remaining at 20 years of age for the decade of the 20th year plus 20. Age-at-death residuals were calculated as observed age-at-death minus expected age-at-death. This analysis was completed in Stata Version 14\textsuperscript{[14]}, and data was visualized using R.\textsuperscript{3.6.1}\textsuperscript{[15]}. Associations were assessed using linear regression models with a quadratic term for seasons-played. Specifically, we use (position) fixed-effect ordinary least squares modeling to determine whether associations exist between age-at-death residual, number of NFL seasons-played (squared), and position category fixed effects. In these models, we seek to assess whether career duration exposure relates significantly to age-at-death residual conditional on position-of-play. The healthy worker turning point was calculated using standard differential calculus techniques (i.e., calculating the minimum point of a best fit surface).

Base Model:

\[
\text{Age at Death Residual } = \beta_0 + \beta_1 \text{Number of Seasons Played } + \epsilon_{i,t}.
\]

Seasons-played Squared Model:

\[
\text{Age at Death Residual } = \beta_0 + \beta_1 \text{Number of Seasons Played } + \epsilon_{i,t} + \beta_2 \text{Number of Seasons Played}^2 + \epsilon_{i,t}.
\]

Position Category Fixed Effects Model

\[
\text{Age at Death Residual } = \beta_0 + \beta_1 \text{Number of Seasons Played } + \epsilon_{i,t} + \beta_2 \text{Number of Seasons Played}^2 + \epsilon_{i,t} + \beta_3 \text{Position Category } + \epsilon_{i,t}.
\]

Results and discussion

Table 1 indicates substantial demographic sample variation between players of different position categories in height, weight, BMI, and age-at-death. Figure 1a-Figure 1b indicate a possible healthy worker effect among players of Category I and II. Certain healthy or durable players can play an increased number of seasons without a corresponding reduction in expected age-at-death as compared to players of shorter career duration\textsuperscript{[16]}. The Seasons-played Squared and Position Category Fixed Effects models specify a quadratic term for number of NFL seasons-played. For both models, the coefficient for this variable is significant and improves the model’s explanatory power according to an Anova F-test for difference in overall model significance (F-statistic = 9.95, p-value = 0.0016; F-statistic=10.98, p-value<0.001) (Table 2). We calculate that

| Characteristic                        | Total | Category 1 Players | Category 2 Players | Category 3 Players |
|--------------------------------------|-------|--------------------|--------------------|--------------------|
| N                                    | 6408  | 1600               | 1690               | 3118               |
| Median Year of Birth (Range)         | 1919 (1876–1992) | 1919 (1883–1992) | 1922 (1880–1992) | 1917 (1876–1986) |
| Average Age-at-death (sd) (years)    | 69.1 (15.8) | 69.5 (15.8)       | 68.0 (16.4)        | 69.6 (15.3)        |
| Median Year of Death (Range)         | 1992 (1923–2018) | 1993 (1925–2018) | 1996 (1924–2018) | 1990 (1923–2018) |
| Median Seasons Played (IQR)          | 2 (3)  | 3 (4)              | 2 (4)              | 2 (3)              |
| BMI (sd) (kg/m\textsuperscript{2})   | 27.6 (2.73) | 25.8 (1.55)       | 27.4 (2.19)        | 28.6 (2.97)        |
| Height (sd) (cm)                     | 184 (6.04) | 181 (5.40)        | 183 (5.68)         | 186 (5.94)         |

BMI – body mass index
Figure 1a. Age-at-death residual versus seasons-played of deceased National Football League (NFL) players (1922–2018) N=6408. Dots represent individual players; Solid line represents a quadratic trend.

The overall association of age-at-death residual and seasons-played is positive beginning at 10.75 and 10.63 seasons-played for the Seasons-played Squared and Position Category Fixed Effects model, respectively. This demonstrates a healthy worker effect, where certain players are not as prone to play-related mortality risk. For this player subset, the healthy worker effect is sufficiently strong to dominate an observed mortality risk effect, where the latter effect drives the negative relationship between seasons-played and age-at-death residual for those playing fewer than 10.75 (10.63) seasons. The healthy worker effect and the mortality risk effect hold conditional upon position category control variables, where controls exhibit substantial variation in effect upon age-at-death residual as in previous literature. However, dividing players into three position categories may not sufficiently capture the differing on-field exposures that may contribute to mortality.

**Conclusion**
This paper finds evidence of both player health risk (in terms of age-at-death residual) for increasing NFL seasons played and
Table 2. Linear regression models predicting age-at-death Residuals among National Football League (NFL) players (1922–2018) N=6408.

| Predictors                | Base                      |           |           |           |           |           |           |           |           |
|---------------------------|---------------------------|-----------|-----------|-----------|-----------|-----------|-----------|-----------|-----------|
|                           | Estimates                 | Standard Error | p     | Estimates | Standard Error | p     | Estimates | Standard Error | p     |
| (Intercept)               | 3.402                     | 0.315     | <0.001    | 4.337     | 0.433     | <0.001    | 4.957     | 0.473     | <0.001    |
| Seasons-played           | -0.562                    | 0.073     | <0.001    | -1.161    | 0.203     | <0.001    | -1.169    | 0.203     | <0.001    |
| Seasons-played Squared   |                           |           |           |           |           | 0.054     | 0.017     | 0.002     |           |
| Position Category 1      |                           |           |           |           |           |           |           |           |           |
|                           |                           |           |           |           |           | 0.055     | 0.017     | 0.001     |           |
| Position Category 2      |                           |           |           |           |           |           |           |           |           |
|                           |                           |           |           |           |           | -2.277    | 0.504     | <0.001    |           |
| Position Category 3      |                           |           |           |           |           |           |           |           |           |
| Observations             | 6408                      |           |           |           |           |           |           |           |           |

Figure 1b. Age-at-death residual versus seasons-played for category 1 and 2 deceased National Football League (NFL) players (1922–2018) N=3,290. Dots represent individual players; Solid line represents a quadratic trend.
healthy worker effects among NFL players. For Category I and II players, the latter effect dominates the former for NFL players with sufficient career survivorship. This effect holds conditional upon position-of-play control variables. Previous research not accounting for the healthy worker effect may not adequately describe mortality risk among NFL players.

**Future work**

We are pursuing additional research to examine the association of on-field playing characteristics with mortality and cause of death among NFL players.

**Ethics**

This study was determined by the Syracuse University Institutional Review Board to not be human subjects research and therefore, not to require review and oversight.

**Data availability**

**Underlying data**

Harvard Dataverse: Replication Data for: Mortality Risk Factors among National Football League Players: An Analysis using Player Career and Biometric Data. https://doi.org/10.7910/DVN/WHU4K

This project contains the following underlying data:

- Football1922_2018.tab (Includes player name, position, year of birth, year of death, death residual, position category, and the number of seasons-played.)

Data are available under the terms of the Creative Commons Zero “No rights reserved” data waiver (CC0 1.0 Public domain dedication).

**References**

1. Teramoto M, Bungum TJ: Mortality and longevity of elite athletes. *J Sci Med Sport*. 2010; 13(4): 410–416. PubMed Abstract | Publisher Full Text

2. Owora AH, Kmush BL, Walia B, et al.: A systematic review of etiological risk factors associated with early mortality among national football league players. *Orthop J Sports Med*. 2016; 6(12): 2325967118813312. PubMed Abstract | Publisher Full Text | Free Full Text

3. Li CY, Sung FC: A review of the healthy worker effect in occupational epidemiology. *Occup Med (Lond)*. 1999; 49(4): 225–229. PubMed Abstract | Publisher Full Text

4. Kerr ZY, Marshall SW, Harding HP, et al.: Nine-year risk of depression diagnosis increases with increasing self-reported concussions in retired professional football players. *Am J Sports Med*. 2012; 40(10): 2206–2212. PubMed Abstract | Publisher Full Text

5. Iversen GL: Chronic traumatic encephalopathy and risk of suicide in former athletes. *Br J Sports Med*. 2014; 48(2): 162–6. PubMed Abstract | Publisher Full Text

6. Shively S, Scher AI, Perl DP, et al.: Dementia resulting from traumatic brain injury: What is the pathology? *Arch Neurol*. 2012; 69(10): 1245–1251. PubMed Abstract | Publisher Full Text | Free Full Text

7. Montenigro PH, Alosco ML, Martin BM, et al.: Cumulative head impact exposure predicts late-life depression, apathy, executive dysfunction, and cognitive impairment in former high school and college football players. *J Neurotrauma*. 2017; 34(2): 328–340. PubMed Abstract | Publisher Full Text | Free Full Text

8. Alosco ML, Tripodi Y, Jamagin J, et al.: Repetitive head impact exposure and later-life plasma total tau in former National Football League players. *Alzheimers Dement (Amst)*. 2016; 7: 33–40. PubMed Abstract | Publisher Full Text | Free Full Text

9. Pro-Football Reference.com: Football encyclopedia of players. 2018; Accessed July 1, 2018.

10. Ehrlich J, Sanders S, Kmush BL, et al.: Replication data for: Mortality risk factors among national football league players: An analysis using player career data [data set]. 2019. http://www.doi.org/10.7910/DVN/WHU4K

11. Baron SL, Hein MJ, Lehman E, et al.: Body mass index, playing position, race, and the cardiovascular mortality of retired professional football players. *Am J Cardiol*. 2012; 109(6): 889–896. PubMed Abstract | Publisher Full Text

12. Martin JA, Hamilton BE, Osterman MJ, et al.: National vital statistics reports. *National Vital Statistics Reports*. 2019; 66(1).

13. Stata statistical software [computer program]. Version 14. College Station, TX: StataCorp; 2015.

14. R: A language and environment for statistical computing [computer program]. Version 3.6.1. R Core Team; 2019.
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This research analyzes the impact of the number of years played in the NFL and position on life expectancy. The question is excellent. The model concisely addresses the question, and the data are comprehensive. This is an important research study that could be replicated for other professional sports. An additional study could break the regressions down by individual position, instead of three categories, to see if there is a further distinction. But that is not necessary for this paper.

Is the work clearly and accurately presented and does it cite the current literature?
Yes

Is the study design appropriate and is the work technically sound?
Yes

Are sufficient details of methods and analysis provided to allow replication by others?
Yes

If applicable, is the statistical analysis and its interpretation appropriate?
Yes

Are all the source data underlying the results available to ensure full reproducibility?
Yes

Are the conclusions drawn adequately supported by the results?
Yes

Competing Interests: No competing interests were disclosed.

Reviewer Expertise: Economics, Environment, Professional Sports, Pandemics
I confirm that I have read this submission and believe that I have an appropriate level of expertise to confirm that it is of an acceptable scientific standard.

Reviewer Report 16 December 2019

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This was a frustrating paper to review: on the one hand, I definitely applaud any analysis of athletes that compares athletes TO athletes and thus avoids the healthy worker effect HWE). (See Nguyen et al. 2019² for a good recent example of avoiding this pitfall; see footnote 2 in this article for a good put-down of the HWE fallacy²). On the other hand, I don't think this analysis actually involves the HWE at all; as I will discuss, it actually purports to find a “frailty” issue within this worker population, which is a very different phenomenon and one with rather different research and policy implications than a true HWE finding.

In this context, a true HWE occurs when reach the mistaken conclusion that X is not riskier than not-X (as in “football players don't die more often of cancer than general population”), or even that X is safer than not-X, but what's really happening is that being in class X shows you were less likely to have the risk than general to begin with. This is important to find and point out, because then you either have to adjust for it (see Choi et al.³) or do a different study that compares apples to apples. But what these researchers may have found (see below) is that within subpopulation of NFL players, some are less frail than others. This is heterogeneity-dynamics at work (see Manton, K.G., E. Stallard, and J.W. Vaupel. 1986. Alternative models for the heterogeneity of mortality risks among the aged. J. Am. Stat. Assoc. 81:635-644⁴). Heterogeneity-dynamics means that you may need to adjust the slope of an observed dose-response function to account for the fact that there are 2 or more subpopulations within the subpopulation—everyone can have an individual positive association between seasons and risk, but the group may have a flat (null) slope simply because those who played the most seasons were not “lucky” but more immune.

The difference between a finding of an HWE between football and the general public, versus the finding of two of more differently-susceptible subgroups within the NFL population, is far from merely semantic, because the practical implications of the two situations are so different. Finding an HWE allows the researcher to correct for it, either by discarding a flawed analysis in favor of an apples-to-apples comparison, or by taking the existing analysis and trying to re-estimate the odds ratio (see, for example, Joffe, 2012⁵). Even without correction, researchers who appreciate the pitfalls of the HWE can simply say that it leads to false negatives preferentially: comparing, for example, the cognitive performance of 60-year-old retired NFL players against the general population of that age would tend to divert attention away from the consequences of repeated...
head trauma (RHT) simply because the general population includes many persons who were never fit enough to work, let alone work in this taxing occupation.

But finding a negative-then-positive relationship between length of (NFL) career and age at death, because the cohort under study has, by definition, more fit persons remaining as more and more of the cohort dies early, may have no empirical or policy implications whatsoever. The authors say nothing about how we might even identify who among incoming NFL players might “benefit” from longer careers and whose dose-response is the most steeply negative—if we could, and if we had the means and the will to discourage the latter group from choosing this occupation, THEN perhaps we could make use of the “finding” that some players are not at risk to the extent that others are (there is an extensive literature about the gap between identifying a powerful interindividual risk factor in a working population—these are usually genetic factors, such as “slow acetylators” who are more at risk from certain occupational chemicals—and the wisdom of trying to exclude these people from the workplace. Generally, policy analysts prefer interventions that can make the workplace safe for everyone who participates—imagine a policy of not allowing people with hemophilia to become carpenters, as opposed to OSHA regulations that mandate guards on saws so that no one will be cut by them).

So this article, at most, finds an “expected curiosity”—that once you have had a long career, you probably are revealing to an epidemiologist that you have been more “immune” to the harmful effects of that career than the average person—and then says nothing about how we could use the finding to adjust scientific conclusions or policy responses. By invoking the HWE throughout the paper, the authors are not only using the wrong term, but inviting statistical corrections or policy responses that have already been made or that would not respond to what they may have actually found.

But all the foregoing assumes that the authors have actually found evidence of a “resistant subpopulation” within the NFL cohort, and I'm not sure that's the case. The authors don't mention alternative explanations for the slight upslope in Figures 1a and 1b, including: (1) reverse causation—if a significant number of players died on the field or soon after sustaining football-related injuries early in their careers, then of course the remaining population would not have “negative death residuals” that large; and (2) effect modification—similarly, if physical inactivity leads to earlier death, then players who sustained career-ending injuries early on would die earlier than others.

More problematic is the use of rote statistics without also applying “common sense” to the finding. How robust, in particular, is the slight upslope obtained by regression to the presence of outliers? The interactive Figures show that the five players with the longest careers were Sammy Baugh, Johnny Unitas, George Blanda, Earl Morrall, and YA Tittle. Some of these (Morrall) I believe played long careers but were backups much of the time, so an index based on number of games rather than seasons might have shown something different. It would be important to explore what happens to the upslope if outliers were trimmed—I say this in part because visual exploration of the Figures does not present a compelling “common sense” picture of a positive slope among the longer careers; I believe the numbers, but the visual impression, especially excluding outliers, is one of a rather flat dose-response that one might be convinced is slightly negative and then very slightly positive. Similarly, I accept (p. 3) that the quadratic model fits slightly better than the linear one, but the authors don't let on how well the linear model fit in the first place. Could they be “finding” something more sophisticated simply by over-fitting? Also, I dispute that the fixed-effects
model is correct, with respect to the kinds of effects (CTE, dementia) the authors clearly are trying to shed light on. The three categories they use seem out-of-place here: other studies have shown that the three positions with the greatest cumulative amount of RHT (instances times g-forces) are tight ends, quarterbacks, and defensive linemen, and yet these are in three different categories in this model!

Finally, the authors focus on mortality, which is fine, but completely ignore quality of life. Just consider the case of Earl Morrall, who lived to age 79 (death residual of > 10) but who reportedly had Stage 4 CTE and a reduced QOL. Someone who comes away from the paper concluding that “once you play 11 seasons, you may live longer than your cohort” may not realize that age at death is not the most relevant outcome...

In summary, the authors should replace “HWE” with “interindividual variability in susceptibility,” explore the implications of THAT analysis, consider how robust their analyses of statistical significance actually are, and ground this paper in terms of the other more ambitious studies that have already explored the relationship between better indices of lifetime intensity of play and mortality/morbidity (especially Montenigro et al., 2017). They might also consider this recent paper by Mez et al. and explore if and how their quadratic model might better explain (or be contradicted by) these prior findings.

References
1. Nguyen VT, Zafonte RD, Chen JT, Kponee-Shovein KZ, et al.: Mortality Among Professional American-Style Football Players and Professional American Baseball Players. JAMA Netw Open. 2019; 2 (5): e194223 PubMed Abstract | Publisher Full Text
2. Finkel A, Bieniek K: A quantitative risk assessment for chronic traumatic encephalopathy (CTE) in football: How public health science evaluates evidence. Human and Ecological Risk Assessment: An International Journal. 2019; 25 (3): 564-589 Publisher Full Text
3. Choi BC: Mathematical procedure to adjust for the healthy worker effect: the case of firefighting, diabetes, and heart disease. Occup Environ Med. 2001; 43 (12): 1057-63 PubMed Abstract | Publisher Full Text
4. Manton KG, Stallard E, Vaupel JW: Alternative models for the heterogeneity of mortality risks among the aged. Am Stat Assoc. 1986; 81 (395): 635-44 PubMed Abstract | Publisher Full Text
5. Joffe M: Structural Nested Models, G-Estimation, and the Healthy Worker Effect. Epidemiology. 2012; 23 (2): 220-222 Publisher Full Text
6. Montenigro P, Alosco M, Martin B, Daneshvar D, et al.: Cumulative Head Impact Exposure Predicts Later-Life Depression, Apathy, Executive Dysfunction, and Cognitive Impairment in Former High School and College Football Players. Journal of Neurotrauma. 2017; 34 (2): 328-340 Publisher Full Text
7. Mez J, Daneshvar DH, Abdolmohammadi B, Chua AS, et al.: Duration of American Football Play and Chronic Traumatic Encephalopathy. Ann Neurol. 2020; 87 (1): 116-131 PubMed Abstract | Publisher Full Text

Is the work clearly and accurately presented and does it cite the current literature?
Partly

Is the study design appropriate and is the work technically sound?
Partly
Are sufficient details of methods and analysis provided to allow replication by others?
Partly

If applicable, is the statistical analysis and its interpretation appropriate?
Partly

Are all the source data underlying the results available to ensure full reproducibility?
Yes

Are the conclusions drawn adequately supported by the results?
Partly

**Competing Interests:** No competing interests were disclosed.

**Reviewer Expertise:** quantitative risk assessment; epidemiology; regulatory policy

I confirm that I have read this submission and believe that I have an appropriate level of expertise to confirm that it is of an acceptable scientific standard, however I have significant reservations, as outlined above.

Author Response 29 Jan 2020

**Justin Ehrlich,** Syracuse University, Syracuse, USA

Thank you for these important points; they will lead to improvements in our paper. This was a very helpful review even though it started off in a negative sense.

We will change the way the HWE is described with respect to the data/results. Specifically, we will frame the HWE as a longitudinal survivorship effect where people are removed from the cohort. We agree there are heterogeneity dynamics at work and will term this as a “survivorship effect” throughout.

We thank the reviewer for suggestions regarding the policy implications and will clarify our policy section accordingly. To make the game safer, we must identify which players are at an elevated risk.

While the reviewer has valid points about outliers, we would prefer to keep them in our analysis. To address outliers, we specified robust standard errors to measure risk factors for mortality in a manner consistent with valid derivation of t-statistics. We disagree with the reviewer and prefer to keep outliers in the dataset. We did not eliminate the outliers so as not to introduce selection bias. Furthermore, this a complete census of the players and we calculated population parameters, not sample statistics; therefore, we prefer to keep all players in the analysis. We will be more clear in the revised draft that we are analyzing the population of NFL players. As such, there is no need to worry about outliers that have an unrepresentative influence vis-à-vis the underlying population. However, we will add in a statement in the limitations about our choice to keep the outliers.

We agree that quality of life and cause of death are important considerations. Here, we analyze all-cause mortality, not CTE specific mortality. Therefore, the papers the reviewer
suggested may not be appropriate because we have all deaths in this population, not a selected sub-sample. While in our future research, we hope to focus on quality of life and cause-specific mortality, that is not possible with this data. We will add in statements about these limitations and future directions.

**Competing Interests:** No competing interests were disclosed.

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