

Association Between Concussion Burden During Professional American-style Football and Post-career Hypertension

Running title: *Grashow et al.; Concussion, Hypertension, and Football*

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*This article is published in its accepted form, it has not been copyedited and has not appeared in an issue of the journal. Preparation for inclusion in an issue of Circulation involves copyediting, typesetting, proofreading, and author review, which may lead to differences between this accepted version of the manuscript and the final, published version.



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Previous work has demonstrated an association between American style football (ASF) and the development of hypertension among collegiate athletes.¹ In addition, hypertension prevalence has been shown to be higher among active professional ASF athletes compared with similarly-aged members of the general population.² While causal factors including deliberate weight gain, repetitive isometric strength training, sleep apnea, and non-steroidal anti-inflammatory use have been suggested, definitive mechanisms remain incompletely understood. Recent studies in general populations have shown associations between brain injury and subsequent hypertension.³ Given that ASF players are at particular risk for recurrent head injury, the relationship between concussion history and later life hypertension deserves focused exploration.

We recruited former professional ASF players to participate in a survey administered by the Football Players Health Study at Harvard University. This study was approved by the Harvard T.H. Chan School of Public Health Institutional Review Board, and all participants provided informed consent prior to participation. Age, race, BMI, smoking, seasons of play, field position, and years since play were defined as previously described.⁴ Concussion burden during ASF participation was quantified by querying the occurrence and severity (i.e., mild, moderate, or severe) of ten common concussion symptoms over years of active ASF participation: headaches, nausea, dizziness, confusion, loss of consciousness (LOC), memory problems, seizure, visual problems, disorientation, and feeling unsteady on one's feet. Estimates of symptom frequency were summed to create a concussion symptom score (CSS).⁴ We used quartiles of the full CSS scale (range=0-130) to reflect low, mild, moderate, and high levels of concussion exposure. Participants were considered to have prevalent hypertension if they reported a prior clinician recommendation for "high blood pressure" medication or were taking "high blood pressure" medication at the time of survey completion. Diabetes status was

determined using prior recommendation for or prescription for “diabetes or high blood sugar” medication. Associations of age (<40, 40-60, >60), race (white, Black, or other), current BMI (<25, 25-30, >30), current smoking status (never, former, current), linemen field position (yes/no), number of NFL seasons, years since last play, and CSS to prevalent hypertension were assessed in a single binomial multivariate logistic regression model. Descriptive statistics were reported as mean±standard deviation (SD) or median and interquartile range (IQR). Odds ratios (OR) and confidence intervals (CI) were estimated from the model. Effects were considered statistically significant at $p<0.05$. Data are not available due to ethical restrictions.

Among 4,168 participants (age 51.8 ± 14.4 [mean±SD], 1,642 [39.4%] Black, BMI = 31.3 ± 5.0 , 1,412 [33.9%] linemen), 368 (8.8%) reported diabetes, and 1,542 (37.3%) met criteria for hypertension. Participants played for 6.7 ± 3.9 seasons, were surveyed at 24.1 ± 32.8 years post-ASF career completion (median=24, IQR=10, 35), and reported a median CSS of 23 (IQR=11, 44). Established risk factors for hypertension including smoking, race, diabetes, age, and BMI were statistically significantly associated with prevalent hypertension (**Figure**). After adjusting for these factors, there was a graded association between CSS category and odds of later-life hypertension and between high CSS exposure and prevalent hypertension. Results were consistent when LOC, a single highly specific severe concussion symptom, was used in isolation as a surrogate for CSS (data not shown).

In this large cohort of former professional ASF players, we found a significant association between concussion symptom burden during years of active play and odds of post-career hypertension. These results suggest that repetitive early-life brain injury may have later-life implications for cardiovascular health. While hypertension is a well-established cause of adverse cardiovascular outcomes, it has also been shown to independently increase the risk of

cognitive decline.⁵ This latter issue is of paramount importance among former ASF players, a population putatively susceptible to premature cognitive impairment which has conventionally been attributed to chronic traumatic encephalopathy, an untreatable neurodegenerative disease. Data from the current study raise the possibility that some element of cognitive decline among former ASF players may be attributable to hypertension, a disease that is responsive to lifestyle intervention and pharmacotherapy. Future studies clarifying associations and causal pathways between brain injury, hypertension, and brain health are warranted. If confirmed, treatment of hypertension may represent a previously unexplored opportunity to prevent or attenuate neurocognitive deterioration among former ASF players. Limitations of this study include the use of self-reported hypertension data and concussion exposure. However, we deliberately employed a conservative trait definition of hypertension, raising the possibility that its prevalence is higher than suggested by our data, and results remained consistent when LOC was substituted for CSS. We further acknowledge that other aspects of early life ASF exposure (e.g., sleep apnea, NSAIDs) coupled with incompletely understood biological and psychosocial determinants of health (e.g., discrimination) may also increase risk of hypertension following brain injury. Finally, we cannot exclude an element of selection bias as only 4185 of 15070 invited former players enrolled. In summary, clinicians caring for athletic, military and civilian populations may wish to consider prior head injury as a risk factor for hypertension. Future longitudinal studies should investigate the role of blood pressure surveillance and treatment to mitigate later-life adverse cardiovascular and cognitive outcomes among populations exposed to early-life head injury.



Acknowledgements

We thank the study participants, advisors, and staff of the Football Players Health Study.

Sources of Funding

This study was supported by Harvard Catalyst/The Harvard Clinical and Translational Science Center and the National Football League Players Association (NFLPA). The NFLPA had no role in the design and conduct of the study; collection, management, analysis, and interpretation of the data; preparation, review, or approval of the manuscript; and decision to submit the manuscript for publication.

Disclosures



Dr. Zafonte reported receiving royalties from Springer/Demos publishing for serving as coeditor of the text *Brain Injury Medicine*; serving on the scientific advisory board of Myomo Inc., and onecare.ai Inc; evaluating patients in the Massachusetts General Hospital Brain and Body–TRUST Program, which is funded by the NFL Players Association; and receiving grants from the NIH. Dr. Baggish has received funding from the National Institute of Health/National Heart, Lung, and Blood Institute, the National Football Players Association, and the American Heart Association and receives compensation for his role as team cardiologist from the US Olympic Committee/US Olympic Training Centers, US Soccer, US Rowing, the New England Patriots, the Boston Bruins, the New England Revolution, and Harvard University. Dr. Taylor reported receiving grants from the NFL Players Association outside the submitted work and grants from the NIH. Dr. Weisskopf reported receiving grants from the NFL Players Association and the NIH

during the conduct of the study. Drs. Grashow, Whittington and Wasfy received grant funding from the NFL Players Association.

No other disclosures were reported.



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Figure. Adjusted odds ratio of self-reported hypertension among former professional American-style football players from a model that included different risk factors including age, race, smoking status, body mass index (BMI), field position, concussion symptom score, years since professional play and number of professional seasons.

Grades of concussion score include mild (33-64), moderate (65-97), and high (>98) compared to the low (0-33) reference group. Ages 25-40, white race, BMI <25.0, non-smokers, non-diabetics, non-linemen, and low concussion symptom burden <33 served as reference groups for age, race, BMI, smoking, position, and concussion symptom quartile respectively.

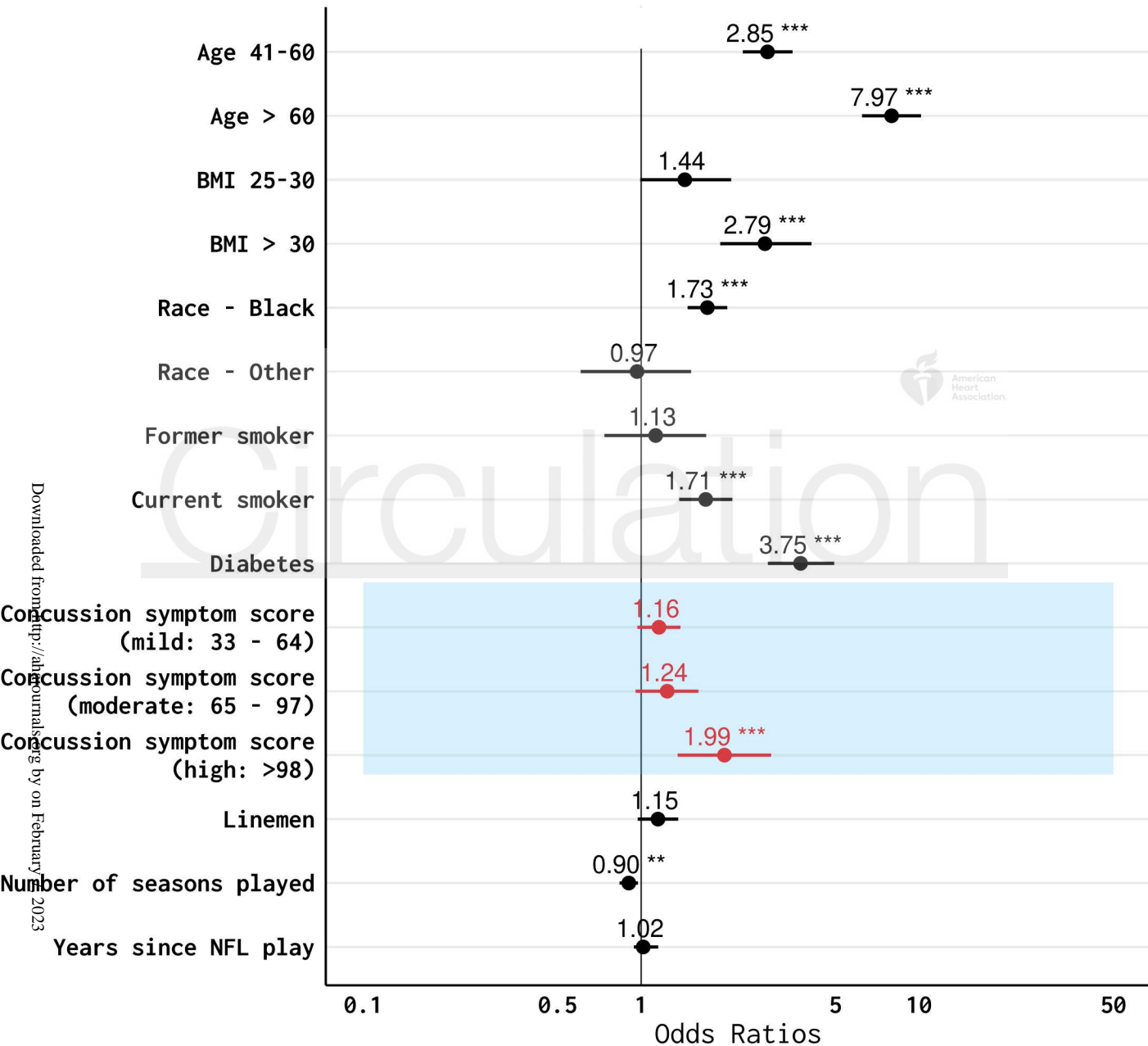
* $p < 0.05$; ** $p < 0.01$, *** $p < 0.001$.



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Self reported hypertension

Told to take or currently taking Rx for HTN



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