

## RESEARCH LETTER

# Association Between Concussion Burden During Professional American-Style Football and Postcareer Hypertension

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Previous work has demonstrated an association between American-style football (ASF) and the development of hypertension among collegiate athletes.<sup>1</sup> In addition, hypertension prevalence has been shown to be higher among active professional ASF athletes compared with similarly aged members of the general population.<sup>2</sup> Whereas causal factors including deliberate weight gain, repetitive isometric strength training, sleep apnea, and nonsteroidal anti-inflammatory drug use have been suggested, definitive mechanisms remain incompletely understood. Recent studies in general populations have shown associations between brain injury and subsequent hypertension.<sup>3</sup> 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 before participation. Age, race, body mass index, smoking, seasons of play, field position, and years since play were defined as previously described.<sup>4</sup> Concussion burden during ASF participation was quantified by querying the occurrence and severity (ie, mild, moderate, or severe) of 10 common concussion symptoms over years of active ASF participation: headaches, nausea, dizziness, confusion, loss of consciousness, 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).<sup>4</sup> We used quartiles of the full CSS scale (range, 0 to 130) to reflect low, mild, moderate, and high levels of concussion exposure. Participants were considered to have prevalent hypertension if they reported a previous 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 previous recommendation for or prescription for diabetes or high blood sugar medication. Associations of age (<40, 40 to 60, >60), race (White, Black, other), current body mass index (<25, 25 to 30, >30), current smoking status (never, former, current), lineman field position (yes/no), number of National Football League seasons, years since last play, and CSS with prevalent hypertension were assessed in a single binomial multivariate logistic regression model. Descriptive statistics were reported as mean±SD or median and interquartile range. Odds ratios (ORs) and CIs were estimated from the model. Effects were considered statistically significant at  $P<0.05$ . Data are not available because of ethics restrictions.

Among 4168 participants (mean age, 51.8±14.4 years; 1642 [39.4%] Black; mean body mass index, 31.3±5.0; 1412 [33.9%] linemen), 368 (8.8%) reported diabetes and 1542 (37.3%) met criteria for hypertension. Participants played for a mean of 6.7±3.9 seasons, were surveyed at 24.1±32.8 years after ASF career completion (median, 24 [interquartile range 10, 35]),

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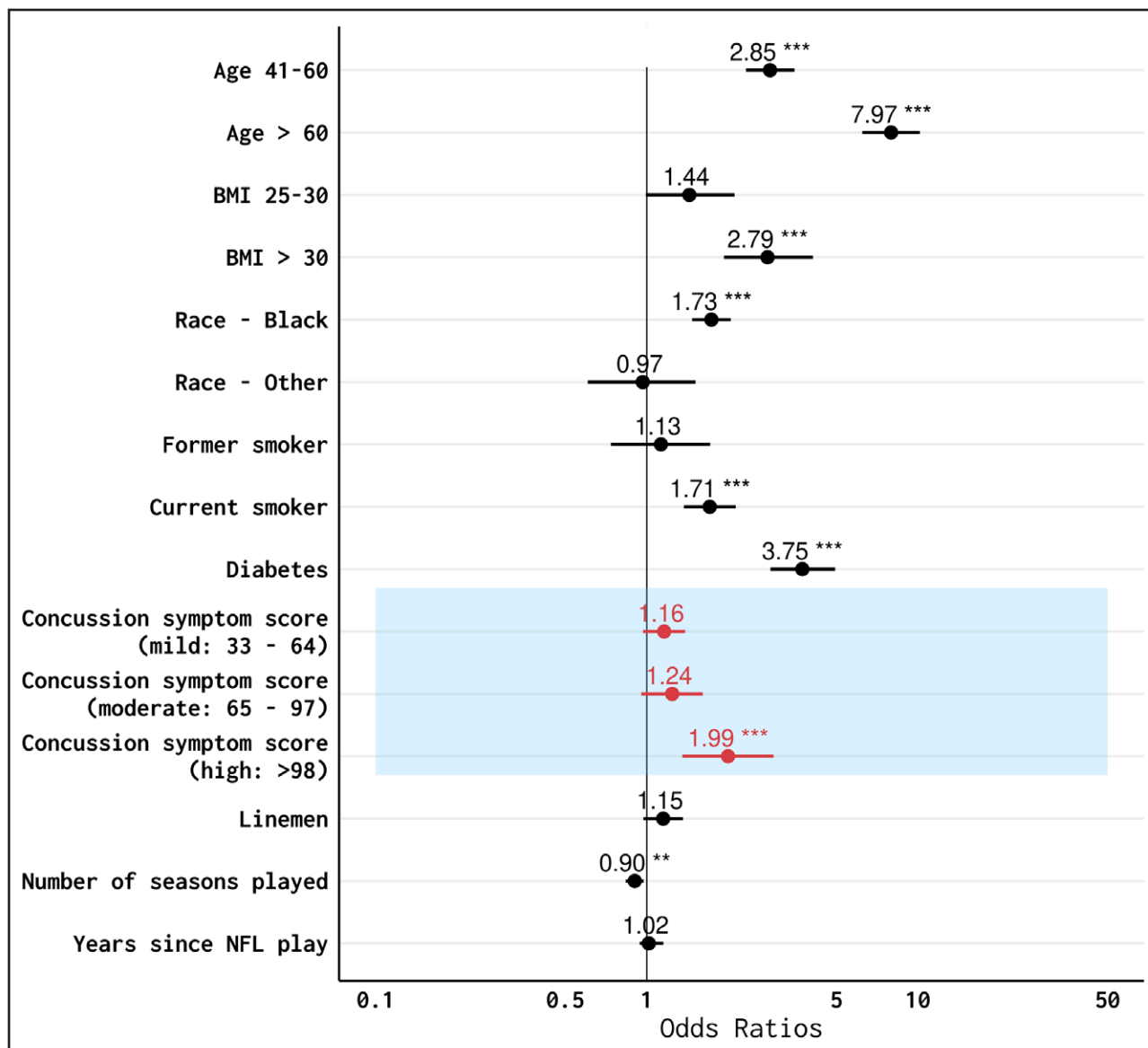
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and reported a median CSS of 23 (interquartile range 11, 44). Established risk factors for hypertension, including smoking, race, diabetes, age, and body mass index, were statistically significantly associated with prevalent hypertension (Figure). 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 loss of consciousness, 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 con-

cussion symptom burden during years of active play and odds of postcareer hypertension. These results suggest that repetitive early-life brain injury may have later-life implications for cardiovascular health. Whereas hypertension is a well-established cause of adverse cardiovascular outcomes, it has also been shown to independently increase the risk of cognitive decline.<sup>5</sup> 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



**Figure. Adjusted odds ratio of self-reported hypertension among former professional American-style football players.**

Adjusted odds ratios are 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 to 64), moderate (65 to 97), or high (>98) compared with the low (0 to 33) reference group. Ages 25 to 40, white race, BMI <25.0, no smoking, no diabetes, nonlinemen, and low concussion symptom burden <33 served as reference groups for age, race, BMI, smoking, position, and concussion symptom quartile, respectively. \*\**P*<0.01, \*\*\**P*<0.001. NFL indicates National Football League.

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 among 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 loss of consciousness was substituted for CSS. We acknowledge that other aspects of early-life ASF exposure (eg, sleep apnea, nonsteroidal anti-inflammatory drug use) coupled with incompletely understood biological and psychosocial determinants of health (eg, discrimination) may also increase risk of hypertension after brain injury. We cannot exclude an element of selection bias, because only 4185 of 15 070 invited former players enrolled.

Clinicians caring for athletic, military, and civilian populations may wish to consider previous 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.

## ARTICLE INFORMATION

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