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High-School Football and Midlife Brain Health Problems

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Abstract

Objective: To examine whether middle-aged men who played high-school football experience worse mental health or cognitive functioning than men who did not play high-school football. **Design:** Cross-sectional cohort study. **Setting:** Online survey completed remotely. **Participants:** A total of 435 men between the ages of 35 and 55 completed the study, of whom 407 were included in the analyses after excluding participants who answered embedded validity items incorrectly (n = 16), played semi-professional football (n = 2), or experienced a recent concussion (n = 10). **Assessment of Risk Factors:** Self-reported high school football participation, compared with those who played contact sports, noncontact sports, and no sports. **Main Outcome Measures:** A lifetime history of depression or anxiety; mental health or cognitive problems in the past year; current depression symptoms, and post–concussion-like symptoms. **Results:** Middle-aged men who played high-school football did not have a higher prevalence of being prescribed medication for anxiety or depression or receiving treatment from a mental health professional. Similarly, there were no significant differences between groups on the rates in which they endorsed depression, anxiety, anger, concentration problems, memory problems, headaches, migraines, neck or back pain, or chronic pain over the past year. A greater proportion of those who played football reported sleep problems over the past year and reported being prescribed medication for chronic pain and for headaches. **Conclusions:** Men who played high-school football did not report worse brain health compared with those who played other contact sports, noncontact sports, or did not participate in sports during high school.

Key Words: football (North American), concussion, risk factors, psychology/psychiatry

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INTRODUCTION

There is societal interest and concern about possible long-term effects of playing professional football on brain health. Researchers have reported that some former National Football League (NFL) players show differences in brain white matter microstructure,[1,2] higher rates of cavum septum pellucidum,[3] and differences in the volume of certain subcortical brain structures.[4,5] They also show differences in neurochemistry, assessed with magnetic resonance spectroscopy,[6] and neurophysiology, assessed with functional magnetic resonance imaging, positron emission tomography, and single-photon emission computerized tomography.[7–12] Some former players perform more poorly on neurocognitive testing than control participants.[2,4,13] Survey studies reveal that a subgroup of the former players rate themselves as having poor mental health and cognitive functioning,[14–19] although the majority do not perceive themselves to have these problems. Postmortem studies have revealed diverse forms of neuropathology in some former players,[20] including chronic traumatic encephalopathy neuropathologic change.[21,22] Mortality studies, based on reviews of death certificates, have found greater rates of cardiovascular disease[23] compared with former major league baseball players but not compared with the general population.[24,25] Compared with the general population, former NFL players have greater rates of Alzheimer's disease[26] and amyotrophic lateral sclerosis[26] as contributory causes of death but not psychiatric illness[25] or suicide.[25,27]

There is also societal interest and concern regarding the long-term brain health of men who played high-school football, although far less research has been performed with them. Two studies have used data from the National Longitudinal Study of Adolescent to Adult Health to examine the associations between playing football during adolescence and mental health approximately 15 years later, during their late 20s. The researchers reported that playing football during adolescence was not associated with greater mental health problems, including lifetime rates of depression,[28,29] current symptoms of depression (ie, within the past 7 days[29]), lifetime rates of anxiety,[29] suicidal ideation within the past year,[28,29] or substance abuse (ie, nicotine, cannabis, and alcohol).[29] Researchers using data

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from the Wisconsin Longitudinal Study reported that playing high-school football was not associated with cognitive problems or depression in older adults, when these men were approximately 65 years old.[30] Using medical record linkage methodology, 2 studies have concluded that former high-school football players are not at increased risk for later in life neurodegenerative diseases.[31,32]

A notable gap in the literature relates to the brain health of middle-aged men who played high-school football. We designed a survey study to examine whether middle-aged men who played high-school football experience worse mental health or cognitive functioning than men who did not play high-school football. Based on the literature to date with men in their late 20s who played football, we adopted the null hypothesis. We assumed that men who played high-school football would not report (1) a greater lifetime history of depression or anxiety, (2) greater mental health or cognitive problems in the past year, or (3) greater current post–concussion-like symptoms or symptoms of depression.

METHODS

Participants

Survey participants were recruited by Amazon Mechanical Turk (mTurk), an online crowdsourcing platform that allows social science and medical researchers to efficiently collect data from large samples of adults.[33] This crowdsourcing survey platform has been steadily growing in popularity, likely because of the increased diversity of mTurk participants regarding age, racial and ethnic identity, socioeconomic status, and geographic distribution across the United States and internationally.[34–37] There is some evidence that data obtained by crowdsourcing platforms such as mTurk are indistinguishable from laboratory and other survey-based data acquisition techniques.[38] Quality control measures, such as limiting participant recruitment to survey completers with diligent past mTurk performances (eg, >95% "approval rating") and setting attention check questions to filter inattentive survey respondents, have improved the reliability, validity, and replicability of responses to these surveys.[39,40] We set an a priori recruitment target of 400 middle-aged men from the US general population, with inclusion criteria being (1) men, (2) age between 35 and 55 years, and (3) current resident of the United States.

Measures

Patient Health Questionnaire-8

The Patient Health Questionnaire-8 (PHQ-8) is an 8-item self-report questionnaire designed to assess symptoms of depression experienced during the past 2 weeks. It is a modification of the PHQ-9[41] by excluding a single item assessing current suicidal ideation. This modification is common in large survey studies where there is no opportunity to provide psychiatric follow-up for participants endorsing morbid thinking and suicide ideation (ie, "thoughts that you would be better off dead or hurting yourself in some way").[42] The PHQ-8 has been shown to be a useful measure for detecting symptoms of depression.[43] Participants are asked to rate the frequency of symptoms and/or behaviors common to the experience of depression on a 0 to 3 scale, with higher scores representing greater symptoms. The cutoff score for screening positively for depression on the PHQ-8 is 10.[43,44] The PHQ-9 has been used as a brief measure of depressive symptoms across a wide range of groups, including the general public,[45] primary care patients,[46] racially and ethnically diverse primary care patients,[47] people with traumatic brain injuries,[48] patients attending memory disorder clinics,[49] and retired professional football players.[50]

British Columbia Postconcussion Symptom Inventory

The British Columbia Postconcussion Symptom Inventory (BC-PSI)[51,52] is a 16-item questionnaire designed to assess the frequency and severity of symptoms of postconcussional syndrome as defined in the 10th revision of the International Statistical Classification of Diseases and Related Health Problems.[53] Participants rate both the frequency and severity of 13 symptoms on a 0 to 5 scale, with higher values representing greater symptom frequency and severity. For each symptom, its frequency and severity ratings are multiplied together (how often × how bad) to create a single symptom value. These product-based values are then converted to item scores that represent both frequency and intensity (0-4). The 13 item scores are added together to create the total score. An additional 3 items assess the impact of these symptoms across aspects of daily living, which were not used in the current study.

Survey

We developed a survey assessing basic demographic information, current physical symptoms (eg, pain, headaches, migraines, and sleep problems), current psychological symptoms (eg, depression, anger, and anxiety), current cognitive symptoms (eg, memory, concentration, and problem solving), history of involvement in various sports, medical history, and concussion history. Regarding the medical history, participants were asked if a medical provider ever recommended or prescribed medication for a variety of conditions. If they responded "yes," they were asked if they were currently taking a medication for that condition. When assessing current symptoms, each physical, psychological, and cognitive symptom was rated twice on a 1 to 5 Likert scale (1 = never, 2 = rarely, 3 = sometimes, 4 = often, and 5 = always) using the prompts "over the past week" and "over the past year." Participants were asked to provide an estimate of the number of concussions they had sustained throughout their life, using the following definition as a guideline that was simultaneously displayed on the screen: We define a concussion as a blow to the head or whiplash that caused any one or more of the following: (1) witnessed loss of consciousness (being "knocked out" and someone seeing it), (2) loss of memory for events immediately before and/or after the injury, or (3) feeling dazed and confused for at least 30 seconds. Participants were also asked to estimate how many years they spent participating in various sports. For each sport, participants were asked to provide an estimate of their participation duration (in years) in the following competition level categories: (1) before high school, (2) during high school, (3) during college, (4) recreationally, (5), semiprofessionally, and (6) professionally. In an effort to reduce bias, participants were surveyed about their psychological health and cognitive

functioning before being asked questions about their sporting history or concussion history.

Procedures

The institutional review board approval was obtained before data collection. All data were collected by an online survey housed within the mTurk platform. Participants were provided an online informed consent document and compensation guidelines. They were informed that the purpose of the study was to assess the prevalence of chronic traumatic encephalopathy-like symptoms in the general population. Participants could withdraw from the survey at any time. Six attention-check validity items were embedded throughout the survey to assess for patterns of random responding. Only surveys in which all embedded validity items were answered satisfactorily were retained for data analysis. The survey was completed in an average of 15 minutes per participant. Financial compensation of $5.00 was provided.

Statistical Analyses

All statistical analyses were performed with SPSS 26.0. Descriptive data were reported without adjustments for departures from normality or outliers. Participants were stratified into 4 groups based on their high-school sports experiences: football, other contact sports, noncontact sports, and no sports. Participants who reported playing at least one year of football were categorized into the football group, and participants who played ice hockey, lacrosse, rugby, soccer, and wrestling (but denied football participation) were categorized into the other contact sports group. The noncontact sports group represented men who endorsed participating in at least 1 year of basketball, baseball, swimming, tennis, cross-country, skiing, or triathlons without any participation in football or other contact sports. We calculated the total years participants played contact sports by summing the number of years that participants endorsed playing football, ice hockey, lacrosse, rugby, soccer, and wrestling at the level of high school or above. Continuous variables (eg, demographics, history, BC-PSI score, and PHQ-8 score) underwent visual inspection for normality, skewness, and kurtosis, as well as the Shapiro–Wilk test of normality. One-way analysis of variances were used to compare groups on age, time since most recent concussion, and body mass index. Number of previous concussions, BC-PSI score, and PHQ-8 score were positively skewed (Shapiro–Wilk, Ps < 0.001). As such, nonparametric Kruskal–Wallis (KW) H Tests with post-hoc Mann–Whitney (MW) U analyses were used to assess for group differences. Group differences on nominal variables (eg, the proportion of each group who endorsed a specific condition) were assessed using χ^2 tests. We examined the relationship between total years of contact sport exposure and health outcomes by using point-biserial and Spearman correlations, for binary and continuous outcome variables, respectively. A post-hoc exploratory analysis was undertaken to examine self-reported memory problems over the past year. Logistic regression was used to classify those with self-reported memory problems and included the following 6 binary predictors: sport (football = 1 and all others = 0), concussion history (yes = 1 and no = 0), chronic pain in past year (yes = 1 and no = 0), sleep problems in the past year (yes = 1 and no = 0), feeling depressed in past year (yes = 1 and no = 0), and anxiety in the past year (yes = 1 and no = 0). Odds ratios (ORs) between 1.2 and 1.71 = small, ORs between 1.72 and 2.4 = medium, and ORs greater than 2.4 = large effects. Significance was defined a priori as $P < 0.05$ for all analyses.

RESULTS

Sample Characteristics

A total of 435 men completed our cross-sectional survey. Participants were current US residents between the ages of 35 and 55 because of a fixed a priori age range. There were 16 individuals who answered embedded validity items incorrectly, so their data were excluded from all analyses. Two participants reported playing semiprofessional football and were excluded. An additional 10 men were excluded because they reported experiencing a concussion within the past year. The final sample included 407 men. This sample was stratified based on their reported high-school sports experiences: football (n = 123), other contact sports (n = 69), noncontact sports (n = 97), and no sports (n = 118). Of note, 15 participants in the high-school football group also reported playing football at the collegiate level. Furthermore, 1 participant in the noncontact group and 3 participants in the no sports group reported playing collegiate contact sports despite not playing these sports in high school. Sample demographics are presented in Table 1. There were no statistically significant differences between the groups on age [$F(3, 403) = 0.77$, $P = 0.51$], body mass index [$F(3, 403) = 1.31$, $P = 0.27$], or time since most recent concussion [$F(3, 228) = 1.04$, $P = 0.38$].

Lifetime Concussion History

The number of previous concussions is reported in Table 2. There was a statistically significant difference between groups on the number of previous concussions (KW Test $\chi^2 = 60.40$, $P < 0.001$). Follow-up tests indicated that those who played football reported more concussions than the contact sport group (U = 3213.00, $P = 0.004$), the noncontact sport group (U = 3439.00, $P < 0.001$), and the no sport group (U = 3543.5, $P = 0.001$). Participants who played contact sports reported more concussions than athletes who did not play contact sports (MW U = 2734.50, $P = 0.03$) and participants who did not play sports (U = 2943.00, $P = 0.001$). The noncontact and no sports groups did not differ significantly on the number of previous concussions (U = 5160.50, $P = 0.16$).

Health Problems

Lifetime health problems, stratified by high-school sport history, are presented in Table 3. There were no statistically significant differences between groups in the proportion that were prescribed medication for anxiety or depression nor were there differences in the proportions who have received treatment from a mental health professional. There were differences in the rates that the groups endorsed being prescribed medication for chronic pain ($\chi^2 = 12.61$, $P = 0.006$), with the football history group having the highest rate (66.7%). Similarly, the football history group reported the highest rate of being prescribed medications for headaches (26.0%), followed by the contact sports group (21.7%), the

TABLE 1. Demographic and Health Characteristics

	Total Sample	Noncontact Sports	Contact Sports	Football	No Sports
Age, mean ± SD	45.1 ± 6.0	45.3 ± 5.8	44.5 ± 5.6	44.8 ± 6.2	45.7 ± 6.2
Body mass index, mean ± SD	28.9 ± 6.6	28.1 ± 6.3	28.4 ± 5.9	29.7 ± 6.3	29.0 ± 7.5
Years since concussion, mean ± SD	23.4 ± 11.2	24.5 ± 12.0	21.0 ± 11.1	23.3 ± 10.0	24.9 ± 12.8
Race/ethnicity, n (%)					
White	348 (85.5)	87 (89.7)	60 (87.0)	100 (81.3)	101 (85.6)
Black/African American	23 (5.7)	4 (4.1)	1 (1.4)	10 (8.1)	8 (6.8)
Multiracial	15 (3.7)	1 (1.0)	5 (7.2)	6 (4.9)	3 (2.5)
Asian/Asian-American	17 (4.2)	5 (5.2)	3 (4.3)	6 (4.9)	3 (2.5)
American Indian/Alaska Native	4 (1.0)	0 (0)	0 (0)	1 (0.8)	3 (2.5)
Played college football	15 (3.7)	0 (0)	0 (0)	15 (12.2)	0 (0)
Total years of contact sports (high school and above), mean ± SD	1.9 ± 3.1	0.1 ± 0.1	3.4 ± 2.3	4.4 ± 3.9	0.1 ± 0.4
Marital status, n (%)					
Married	201 (49.4)	48 (49.5)	40 (58.0)	68 (55.3)	45 (38.1)
Separated/divorced	29 (7.1)	9 (9.3)	6 (8.7)	6 (4.9)	8 (6.8)
Never married	132 (32.4)	29 (29.9)	18 (26.1)	33 (26.8)	52 (44.1)
Living with partner	41 (10.1)	11 (11.3)	3 (4.3)	14 (11.4)	13 (11.0)
Widowed	4 (1.0)	0 (0)	2 (2.9)	2 (1.6)	0 (0)
Previous concussions					
0	175 (43.0)	52 (53.6)	26 (37.7)	23 (18.7)	74 (62.7)
1	103 (25.3)	23 (23.7)	20 (29.0)	37 (30.1)	23 (19.5)
2	59 (14.5)	10 (10.3)	11 (15.9)	25 (20.3)	13 (11.0)
3+	70 (17.2)	12 (12.4)	12 (17.4)	38 (30.9)	8 (6.8)
Exercise, days per week, n (%)					
0	60 (14.7)	13 (13.4)	8 (11.6)	16 (13.0)	23 (19.5)
1-2	103 (25.3)	31 (32.0)	20 (29.0)	27 (22.0)	25 (21.2)
3-4	148 (36.4)	33 (34.0)	27 (39.1)	49 (39.8)	39 (33.1)
5-6	81 (19.9)	18 (18.6)	13 (18.8)	28 (22.8)	22 (18.6)
7	15 (3.7)	2 (2.1)	1 (1.4)	3 (2.4)	9 (7.6)
Alcohol use, days per week, n (%)					
0	200 (49.1)	46 (47.4)	25 (36.2)	57 (46.3)	72 (61.0)
1-2	129 (31.7)	32 (33.0)	25 (36.2)	47 (38.2)	25 (21.2)
3-4	38 (9.3)	8 (8.2)	8 (11.6)	10 (8.1)	12 (10.2)
5-6	23 (5.7)	8 (8.2)	3 (4.3)	6 (4.9)	6 (5.1)
7	17 (4.2)	3 (3.1)	8 (11.6)	3 (2.4)	3 (2.5)
No. of Alcoholic beverages when drinking, n (%)					
I do not drink	173 (42.5)	37 (38.1)	21 (30.4)	53 (43.1)	62 (52.5)
1	63 (15.5)	14 (14.4)	17 (24.6)	18 (14.6)	14 (11.9)
2-3	104 (25.6)	31 (32.0)	19 (27.5)	34 (27.6)	20 (16.9)
4-5	35 (8.6)	7 (7.2)	8 (11.6)	6 (4.9)	14 (11.9)
6-8	17 (4.2)	4 (4.1)	3 (4.3)	5 (4.1)	5 (4.2)
9+	15 (3.7)	4 (4.1)	1 (1.4)	7 (5.7)	3 (2.5)
Marijuana use, days per week, n (%)					
0	337 (82.8)	79 (81.4)	57 (82.6)	95 (77.2)	106 (89.8)
1-2	22 (5.4)	7 (7.2)	3 (4.3)	9 (7.3)	3 (2.5)
3-4	3 (0.7)	0 (0)	0 (0)	2 (1.6)	1 (0.8)
5-6	10 (2.5)	4 (4.1)	2 (2.9)	3 (2.4)	1 (0.8)
7	35 (8.6)	7 (7.2)	7 (10.1)	14 (11.4)	7 (5.9)
Other drug use, days per week, n (%)					
0	397 (97.5)	96 (99.0)	67 (97.1)	117 (95.1)	117 (99.2)

TABLE 1. Demographic and Health Characteristics *(Continued)*

	Total Sample	Noncontact Sports	Contact Sports	Football	No Sports
1-2	7 (1.7)	0 (0)	2 (2.9)	4 (3.3)	1 (0.8)
3-4	1 (0.2)	0 (0)	0 (0)	1 (0.8)	0 (0)
5-6	2 (0.5)	1 (1.0)	0 (0)	1 (0.8)	0 (0)
Smoked 20 or more packs of cigarettes, n (%)					
Yes, I currently smoke	69 (17.0)	13 (13.4)	11 (15.9)	26 (21.1)	19 (16.1)
Yes, but I do not currently smoke	131 (32.2)	33 (34.0)	28 (40.6)	42 (34.1)	28 (23.7)
No	207 (50.9)	51 (52.6)	30 (43.5)	55 (44.7)	71 (60.2)
Lifetime history of performance-enhancing drugs	18 (4.4)	2 (2.1)	6 (8.7)	5 (4.1)	5 (4.2)

Total sample N = 407, noncontact sports N = 97, contact sports N = 69, football N = 123, no sports N = 118.

noncontact sports group (10.3%), and the no sports group (7.6%; $\chi^2 = 19.14$, $P < 0.001$). There were no significant group differences in a lifetime history of other health conditions between groups.

The proportions of the sample who reported having difficulties with psychological health, cognition, headaches, migraines, and chronic pain as "often" or "always" over the past year are presented in Table 4. There were no significant differences between groups on the rates in which they endorsed depression, anxiety, anger, concentration problems, memory problems, headaches, migraines, neck or back pain, or chronic pain over the past year (all $P > 0.05$). Groups differed on their rates of sleep problems ($\chi^2 = 8.64$, $P = 0.03$), with 39.0% of the football group reporting significant sleep difficulties compared with 20.6% to 30.5% of participants in the other groups. There were trends ($P < 0.10$) for the rates of migraines ($\chi^2 = 7.62$, $P = 0.06$) and memory problems ($\chi^2 = 6.87$, $P = 0.08$), such that the football group seemed to endorse these conditions more than the other groups. Results were similar when examining symptoms in the past week. See Table 2 for descriptive statistics related to current post–concussion-like symptoms (BC-PSI) and symptoms of depression (PHQ-8). The groups did not differ significantly on their total post–concussion-like symptoms (BC-PSI; KW Test $\chi^2 = 5.44$, $P = 0.14$) or total depressive symptoms (KW Test $\chi^2 = 2.65$, $P = 0.45$).

When examining the entire sample, there were no statistically significant correlations between total years of contact sport exposure and the PHQ-8 Total Score (rho = 0.04, $P = 0.37$) and BC-PSI total score (rho = 0.09, $P = 0.08$). There were small correlations between contact sport exposure duration and being prescribed medication for pain ($r_{pb} = 0.11$, $P = 0.03$) and headaches ($r_{pb} = 0.17$, $P = 0.001$), but no correlation between contact sport exposure duration and being prescribed medication for ADHD, anxiety, depression, memory loss, or any other health conditions listed in Table 3 (all Ps > 0.05). Within the high-school football group alone, there were no statistically significant correlations between total years of contact sport exposure and the PHQ-8 Total Score (rho = −0.13, $P = 0.14$), BC-PSI total score (rho = −0.08, $P = 0.38$), or being prescribed medication for pain ($r_{pb} = 0.03$, $P = 0.71$), headaches ($r_{pb} = 0.03$, $P = 0.75$), and all other health conditions listed in Table 3 (all Ps > 05). Similarly, there were no significant correlations between years of contact sport exposure and these variables in the contact sport alone group (all Ps > 0.05).

Predicting Memory Problems

The overall model for the exploratory logistic regression predicting memory problems over the past year was statistically significant [$\chi^2(6) = 62.67$, $P < 0.001$] and explained 26.9% of the variance (ie, Nagelkerke R Square). The following variables, presented by descending ORs were statistically significant: sleep difficulties (OR = 3.19), anxiety (OR = 2.90), history of one or more concussions (OR = 2.33), and feeling depressed (OR = 2.26). The history of playing high-school football and pain in the past year was not significant independent predictors. The results are presented in Table 5.

DISCUSSION

Men who played high-school football did not report worse brain health compared with those who played other contact sports, noncontact sports, or did not participate in sports

TABLE 2. Concussion History, PHQ-8, and BC-PSI Total Scores Across Sports History Groups

	No. of Previous Concussions				PHQ-8 Total Score				BC-PSI Total Score			
	Mean	Median	SD	IQR	Mean	Median	SD	IQR	Mean	Median	SD	IQR
Total sample	1.38	1	2.15	0-2	5.12	3	5.30	1-8	9.24	6	9.72	2-14
Noncontact sports	0.89	0	1.26	0-1	4.71	3	5.27	1-6	7.96	5	8.91	1-12
Contact sports	1.67	1	2.70	0-2	5.01	3	5.47	1-8	10.30	6	10.81	2-17.5
Football	2.28	2	2.70	1-3	5.62	4	5.36	2-9	10.63	8	10.39	2-16
No sports	0.68	0	1.13	0-1	5.00	4	5.20	0-8	8.22	5	8.78	1-12

Total sample N = 407, noncontact sports N = 97, contact sports N = 69, football N = 123, no sports = 118.
IQR, interquartile range.

TABLE 3. Frequencies of Health Conditions Across Sport History Groups

Lifetime History of Being Recommended/Prescribed Medication for…	Total Sample, n (%)	Noncontact Sports, n (%)	Contact Sports, n (%)	Football, n (%)	No Sports, n (%)	χ^2	*P*
ADHD	37 (9.1)	5 (5.2)	10 (14.5)	12 (9.8)	10 (8.5)	4.38	0.22
Anxiety	115 (28.3)	30 (30.9)	16 (23.2)	37 (30.1)	32 (27.1)	1.49	0.68
Depression	117 (28.7)	29 (29.9)	21 (30.4)	33 (26.8)	34 (28.8)	0.38	0.94
Memory loss	2 (0.5)	1 (1.0)	0 (0)	1 (0.8)	0 (0)	1.76	0.62
Chronic pain	228 (56.0)	54 (55.7)	40 (58.0)	82 (66.7)	52 (44.1)	12.61	0.006
Headaches	66 (16.2)	10 (10.3)	15 (21.7)	32 (26.0)	9 (7.6)	19.14	<0.001
Diabetes	43 (10.6)	5 (5.2)	8 (11.6)	15 (12.2)	15 (12.7)	4.00	0.26
High cholesterol	82 (20.1)	19 (19.6)	16 (23.2)	24 (19.5)	23 (19.5)	0.48	0.92
High blood pressure	117 (28.7)	21 (21.6)	20 (29.0)	41 (33.3)	35 (29.7)	3.70	0.30
Congestive heart failure	8 (2.0)	2 (2.1)	2 (2.9)	3 (2.4)	1 (0.8)	1.23	0.75
Arrhythmia/Atrial fibrillation	18 (4.4)	5 (5.2)	1 (1.4)	8 (6.5)	4 (3.4)	3.13	0.37
Liver dysfunction/Failure	9 (2.2)	2 (2.1)	1 (1.4)	4 (3.3)	2 (1.7)	0.96	0.81
Low testosterone	19 (4.7)	3 (3.1)	4 (5.8)	8 (6.5)	4 (3.4)	2.10	0.55
Erectile dysfunction	39 (9.6)	8 (8.2)	9 (13.0)	12 (9.8)	10 (8.5)	1.33	0.72
Psychological treatment	171 (42.0)	45 (46.4)	31 (44.9)	50 (40.7)	45 (38.1)	1.83	0.61

Total sample N = 407, noncontact sports N = 97, contact sports N = 69, football N = 123, no sports = 118.
ADHD, attention-deficit/hyperactivity disorder; psychological treatment, history of seeing a psychologist, counselor, or therapist.

during high school. Specifically, there were no statistically significant differences among groups in the percentages who reported a lifetime history of mental health treatment with a psychologist or counselor, or a history of being prescribed medications for anxiety or depression (Table 3). Moreover, the groups did not differ in the rates in which they reported depression, anxiety, anger control problems, or cognitive problems in the past year (Table 4). Regarding their current

TABLE 4. Mental Health, Cognitive, and Chronic Pain Problems in the Past Year and the Past Week

	Total Sample, n (%)	Noncontact Sports, n (%)	Contact Sports, n (%)	Football, n (%)	No Sports, n (%)	χ^2	*P*
Past year							
Felt depressed	89 (21.9)	16 (16.5)	14 (20.3)	28 (22.8)	31 (26.3)	3.14	0.37
Anxiety	84 (20.6)	16 (16.5)	14 (20.3)	25 (20.3)	29 (24.6)	2.15	0.54
Anger problem	40 (9.8)	8 (8.2)	5 (7.2)	17 (13.8)	10 (8.5)	3.25	0.36
Concentration problems	60 (14.7)	10 (10.3)	10 (14.5)	19 (15.4)	21 (17.8)	2.44	0.49
Memory problems	51 (12.5)	8 (8.2)	6 (8.7)	23 (18.7)	14 (11.9)	6.87	0.08
Headaches	42 (10.3)	11 (11.3)	10 (14.5)	13 (10.6)	8 (6.8)	3.01	0.39
Migraines	19 (4.7)	2 (2.1)	7 (10.1)	7 (5.7)	3 (2.5)	7.62	0.06
Chronic pain	152 (37.3)	30 (30.9)	27 (39.1)	55 (44.7)	40 (33.9)	5.26	0.15
Back or neck pain	117 (28.7)	27 (27.8)	19 (27.5)	44 (35.8)	27 (22.9)	5.04	0.17
Sleep problems	125 (30.7)	20 (20.6)	21 (30.4)	48 (39.0)	36 (30.5)	8.64	0.03
Past week							
Felt depressed	72 (17.7)	14 (14.4)	11 (15.9)	23 (18.7)	24 (20.3)	1.51	0.68
Anxiety	73 (17.9)	18 (18.6)	10 (14.5)	22 (17.9)	23 (19.5)	0.78	0.86
Anger problem	33 (8.1)	8 (8.2)	4 (5.8)	12 (9.8)	9 (7.6)	0.98	0.81
Concentration problems	49 (12.0)	7 (7.2)	8 (11.6)	12 (9.8)	22 (18.6)	7.61	0.06
Memory problems	42 (10.3)	6 (6.2)	5 (7.2)	18 (14.6)	13 (11.0)	5.03	0.17
Headaches	37 (9.1)	8 (8.2)	5 (7.2)	16 (13.0)	8 (6.8)	3.41	0.33
Migraines	12 (2.9)	1 (1.0)	3 (4.3)	6 (4.9)	2 (1.7)	3.97	0.27
Chronic pain	142 (34.9)	30 (30.9)	26 (37.7)	47 (38.3)	39 (33.1)	1.68	0.64
Back or neck pain	116 (28.5)	29 (29.9)	24 (34.8)	34 (27.6)	29 (24.6)	2.37	0.50
Sleep problems	111 (27.3)	21 (21.6)	16 (23.2)	46 (37.4)	28 (23.7)	9.23	0.03

Total sample N = 407, noncontact sports N = 97, contact sports N = 69, football N = 123, no sports = 118.
The problems in this table were rated as "often" or "always" over the past year.

functioning, the groups did not differ in their reporting of symptoms of depression or post–concussion-like symptoms (Table 2).

Secondary analyses revealed some statistically significant differences among groups. Those who played football reported a significantly greater lifetime history of concussions than those who played other contact sports or no sports in high school (Tables 1 and 2). Of those who played high-school football, 81.3% reported a lifetime history of one or more concussions compared with 37.3% to 62.3% of the other groups (Table 1). There were differences in the rates that the groups endorsed being prescribed medication for chronic pain, with the football history group having the highest rate over the course of their lifetime (66.7%) (Table 3). There was a trend for the rate at which they reported chronic pain in the past year to be higher than those who played noncontact sports or did not play sports (Table 4). In addition, those who played football reported the highest rate of being prescribed medications for headaches (26.0%) (Table 3), but they did not report a greater problem with headaches over the past year (Table 4). Finally, those who played football reported higher rates of sleep difficulties over the past year compared with the other groups. When only analyzing the football group, duration of contact sport exposure was not associated with later life health conditions, nor was it associated with current depression or concussion-like symptoms.

There was a trend for those who played football to report greater rates of memory problems over the past year (Table 4). We therefore conducted a post-hoc exploratory analysis to identify predictors of perceived memory problems. Predictors with large effect sizes included having sleep difficulties and experiencing anxiety in the past year. Having a history of concussions and feeling depressed in the past year were significant predictors with medium effect sizes and playing football in high school was not a significant predictor (Table 5).

This study has several important limitations. First, this was an online survey study, and all results are subject to reporting bias. Second, consent documentation noted the purpose of the study was to assess the prevalence of chronic traumatic encephalopathy (CTE)-like symptoms. As such, individuals with a concussion history or those who perceived themselves to be experiencing related symptoms may have been more likely to participate. In addition, media attention given to CTE may have influenced participant responses. Third, although we operationalized a definition of concussion for the participants, the injuries were self-reported and could not be independently verified. There is some evidence to suggest that individuals may have difficulty recalling remote brain injuries that required hospitalization,[54] so it is entirely possible that our results underestimate lifetime history of concussion. Fourth, we did not control for multiple statistical comparisons by adjusting the *P*-value. The absence of statistically significant findings strengthens the likelihood that the null findings are null. Finally, as seen in Table 2, the interquartile range for the PHQ-8 was 1 to 8, indicating that about 25% of this sample had a score of 9 or higher. Given that a score of 10 is the cutoff for depression,[43] a larger proportion of this sample may be experiencing depression compared with the general population, potentially limiting the generalizability of this study to the general population.

The results of this study are in line with 6 previous studies relating to participation in high-school football and later in life brain health. Two large-scale longitudinal studies that have surveyed men during their late 20s have reported that playing football during adolescence is not associated with greater current or lifetime mental health problems,[28,29] and a large-scale longitudinal study of older adult men revealed no association between playing football in high school and current problems with depression or cognitive functioning.[30] Regarding neurodegenerative diseases, 2 studies have reported no association between playing high-school football and risk for dementia, Parkinson's disease, or amyotrophic lateral sclerosis (ALS).[31,32] Moreover, in a recently published study, Bieniek and colleagues[55] conducted a neuropathology study relating to CTE using autopsy cases from the Mayo Clinic Tissue Registry. Using primary historical obituary and yearbook records, they identified and compared former athletes and nonathletes. They used a medical records linkage system to examine billing codes relating to various psychiatric and neurological diagnoses. Using frequency data presented in their unpublished online supplementary Table 3, we statistically compared the 140 men who played football to the 245 men who did not play sports. The men who played football had significantly lower rates of (1) depression [25.0% vs 37.1%, $\chi^2(1) = 5.97$, $P = 0.015$, OR = 1.77; 95% CI, 1.12-2.81], (2) anxiety [9.3% vs 18.0%, $\chi^2(1) = 5.31$, $P = 0.021$, OR = 2.14; 95% CI, 1.11-4.13], (3) alcoholism [18.6% vs 27.8%, $\chi^2(1) = 4.07$, $P = 0.044$, OR = 1.68; 95% CI, 1.01-2.80], and (4) drug abuse [3.6% vs 9.4%, $\chi^2(1) = 4.47$, $P = 0.035$, OR = 2.80; 95% CI, 1.04-7.53]. There was no statistically significant difference in their rate of suicide (3.6% in those who played football vs 8.2% in those who did not play sports, $\chi^2(1) = 3.09$, $P = 0.079$). Regarding neurological disorders, there was no significant difference between those who played football versus those who did not play sports in their rates of (1) movement disorders [15.7% vs 15.5%, $\chi^2(1) = 0.003$, $P = 0.958$)] or (2) dementia [29.3% vs 24.9%, $\chi^2(1)$

TABLE 5. Binary Logistic Regression Predicting Memory Problems in the Past Year

	B	SE	Wald	*P*	OR	95% CI for OR
History of high-school football	0.48	0.36	1.79	0.18	1.62	0.80-3.26
History of concussion	0.85	0.41	4.29	0.04	2.33	1.05-5.18
Chronic pain	−0.15	0.38	0.16	0.69	0.86	0.41-1.81
Sleep problems	1.16	0.38	9.17	0.002	3.19	1.51-6.75
Felt depressed	0.81	0.39	4.31	0.04	2.26	1.05-4.87
Anxiety	1.06	0.39	7.38	0.007	2.90	1.35-6.24

All variables were binary. The problems in this table were rated as "often" or "always" over the past year.

= 0.88, $P = 0.348$]. There was also no significant difference in the rates in which they had Alzheimer's disease neuropathologic change [former football players, mean age = 69 years, 19.3%, no participation in sports, mean age = 64 years, 21.6%; $\chi^2(1) = 0.30$, $P = 0.584$].

Without question, some men who played high-school football will experience later-in-life problems with psychological health and cognitive functioning, but their rates of this do not seem to be greater than the rates in men who did not play football. In the general population, there are strong associations between depression and (1) anxiety,[56] (2) headaches,[57,58] migraine,[59–63] (3) memory difficulties,[64–66] and (4) chronic pain.[67,68] Moreover, there are also strong associations between anxiety and (1) headaches,[69] (2) migraine,[70–72] (3) chronic pain,[68,73] and (4) memory problems.[74] These problems tend to be comorbid, and they can amplify each other. The important point for clinicians is that the aforementioned problems are commonly inter-related and mutually amplifying, and evidence-based treatment and rehabilitation for these problems can substantially reduce symptoms and improve functioning and quality of life.

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