Weight Gain and Health Affliction Among Former National Football League Players

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ABSTRACT

BACKGROUND: Professional American-style football players are among the largest athletes across contemporary sporting disciplines. Weight gain during football participation is common, but the health implications of this early-life weight gain remain incompletely understood. We sought to define weight trajectories of former professional American-style football athletes and to establish their relationship with 5 common health afflictions (cardiovascular disease, cardiometabolic disease, neurocognitive impairment, sleep apnea, and chronic pain).

METHODS: A health survey was distributed to former National Football League (NFL) players. Former players reported body weight at 4 time points (high school, college, professional, and time of survey response) as well as maximal retirement weight. Logistic regression was used to assess associations between weight gain during football participation and health affliction.

RESULTS: In this cohort of former NFL players (n = 3,506, age 53 ± 14 years), mean weight increase from high school to time of survey response was 40 ± 36 pounds, with the majority of weight gain occurring during periods of football participation (high-school-to-college and college-to-professional). The prevalence of health afflictions ranged from 9% (cardiovascular disease) to 28% (chronic pain). Weight gain during football participation was independently associated with risk of multiple later-life health afflictions in models adjusted for football exposure, lifestyle variables, and post-career weight gain.

CONCLUSIONS: Early-life weight gain among American-style football athletes is common and is associated with risk of adverse health profiles during later-life. These findings establish football-associated weight gain as a key predictor of post-career health and raise important questions about the central role of targeted weight gain in this population.

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KEYWORDS: American-style football; Cardiovascular disease; Chronic pain; Obesity; Obstructive sleep apnea; Sports medicine; Weight gain

INTRODUCTION

The impact of participation in American-style football on health and longevity is incompletely understood. However, a rapidly expanding scientific literature coupled with publicly vetted health concerns among former and current National Football League (NFL) players suggest that football participation may be a risk factor for neurocognitive impairment,[1] cardiovascular and cardiometabolic disease,[2] sleep apnea,[3] and chronic pain.[4] At present, the factors

inherent in football participation that predisposes players to these forms of disease remain uncertain.[5]

At both the college and professional levels, American-style football athletes are among the largest athletes across all contemporary sporting disciplines. In recent decades, the average size of elite football participants has increased markedly, with body mass indices that now commonly meet accepted definitions of obesity.[6-8] Although the sport of football may select for inherently large individuals, some athletes gain significant amounts of weight during their careers.[9] Limited prior data suggest that the largest football athletes are at the highest risk of adverse health profiles.[3, 10-12] Among the general population, obesity is associated with diseases of numerous organ systems[13-15] and increased mortality,[16] and is the leading cause of preventable death in the United States.[17] However, the application of general-population obesity data to elite athletes may be inappropriate because weight gain and corollary body size among football athletes may carry different prognostic implications. At present, very little research has been conducted on the association between lifetime body mass trajectory and postcareer pathology in elite football athletes, with emphasis on quantifying weight gain during the period of football participation.

We hypothesized that body size among former NFL players, specifically weight gain that occurred during their progression from high school to college to professional levels of American-style football, would be independently associated with the presence of later-life affliction across multiple domains of health. To address this hypothesis, we analyzed data from a sample of living former NFL players to define their weight trajectories and to characterize associations between weight gain and the presence of 5 common clinical afflictions: cardiovascular disease, cardiometabolic disease, neurocognitive impairment, sleep apnea, and chronic pain.

METHODS

Survey Development and Administration

The Football Players Health Study at Harvard University is a multidisciplinary study aimed at understanding health issues facing current and former NFL players. Records supplied by the NFL Players Association and a public online source (Pro Football Reference: 2 January, 2017) were used to identify living former NFL players whose careers spanned from 1960 to the present. A 76-question survey was sent to all former players with verifiable contact information. Participation was optional, and no compensation was given. Responses were collected and tabulated using REDCap (Vanderbilt, Nashville, Tenn) (for online surveys) or Scantron (Scantron Corporation, Tustin, Calif) (for paper surveys). This study was approved by the institutional review board for the Beth Israel Deaconess Medical Center, an affiliate of Harvard Medical School.

Respondent Characteristics and Covariates

A total of 3506 of 12,357 (28.4%) contacted former players completed the survey by the time of this analysis and thus comprised the study population (Figure 1). Age was determined based on date of survey response and reported date of birth. Race was categorized as white, black, and other, with the latter encompassing responses of American Indian/Alaskan Native, Native Hawaiian/Pacific Islander, Asian, Hispanic, or other. Respondents reported weight at 4 time points: 1) the conclusion of high school football participation; 2) the conclusion of college football participation; 3) highest weight during professional football participation; and 4) at the time of survey completion (ie, current weight). Respondents were also asked to report highest postretirement weight. Body mass index (body weight in kilograms divided by height in meters squared) was calculated using current weight and reported height.[18] Alcohol use was categorized in terms of drinks per week (none, 1-7, 8-14, or 15+). Exercise frequency was classified based on responses to a question regarding number of days of exercise in an average week. To assess engagement with the health care system, respondents were asked if they had a primary care physician that they see at least every 3 years. Playing position was divided into linemen and nonlinemen, with the former group encompassing all offensive and defensive linemen and the latter group all other players.[2, 19, 20] Respondents who played both a lineman position and a nonlineman position were classified as linemen.

Outcome Assessment and Definitions

For heart attack, stroke, sleep apnea, dementia, and chronic traumatic encephalopathy, the survey asked former players whether a health care provider had ever given them a specific diagnosis for these conditions. Similarly, for cardiac revascularization interventions (bypass surgery,

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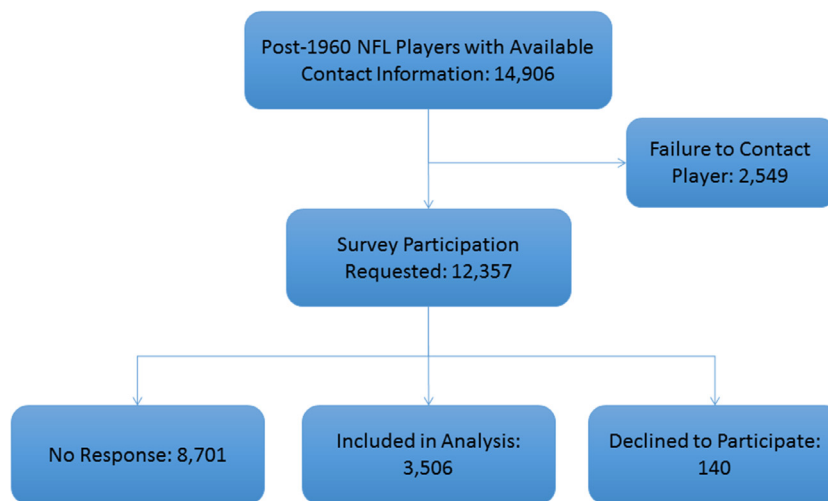
Figure 1 Eligible former National Football League players and response rates to the study survey tool.

angioplasty, and stent), participants were asked if they had had such a procedure since retirement from the NFL. For other medical conditions (hypertension, hyperlipidemia, diabetes, pain, and memory loss), respondents were asked whether a provider had ever recommended or prescribed therapy for a given condition and whether they were currently taking medication for said condition. Using these data, clinical affliction definitions for 5 binary outcome variables were designed with the goal of providing conservative estimates of disease prevalence (Table 1).

Statistical Analysis

In an attempt to isolate the effects of weight change directly related to American-style football participation, 2 weight change time periods were selected for primary analysis: high school weight to college weight and college weight to professional weight. Changes in group mean weight between time periods were compared using paired t tests. Logistic regression was used to estimate odds ratios and 95% confidence intervals (CIs) between these weight changes (both of which were included jointly in each model) and each clinical affliction outcome separately. Models were constructed by selecting candidate variables using a priori biologic hypotheses. Model 1 adjusted for high school weight, age at survey completion, and race. Model 2 included all covariates from model 1 and additionally incorporated football exposure variables, including age of first competitive football participation, number of seasons in a player's professional career, and field position. Model 3 included all covariates from model 2 and additionally incorporated postcareer weight gain (professional weight to maximum retirement weight) and additional lifestyle factors, including smoking status, habitual exercise, and alcohol use. Highest retirement weight was chosen for inclusion to completely account for postcareer weight gain.

Effect modification by field position (linemen vs nonlinemen) was assessed by inclusion of an interaction term between field position and weight gain. Prevalence of the clinical afflictions among linemen and nonlinemen was compared using the chi-square test. Statistical significance was defined by the 95% level of confidence ($P < .05$). All analyses were performed using SAS version 9.0 (SAS Institute, Cary, NC)

RESULTS

Characteristics of survey respondents are summarized in Table 2. Mean (standard deviation) age at time of survey completion was 53 (14) years. More than one-third (36.2%) of the study population self-reported black/African American ethnicity. Most respondents started playing competitive football in their preteen years (mean age, 11.7 years). Approximately one-third of respondents played a lineman position, and the average professional career spanned approximately 7 seasons. Most respondents never smoked tobacco (83%), and active tobacco smoking at the time of survey completion was rare (3.2%). Alcohol use varied more, with 32% reporting no alcohol intake and more than 20% consuming 15 or more drinks per week. Similarly, the amount of habitual exercise varied significantly, with approximately 10% reporting no habitual exercise and 25% reporting routine exercise 5 or more days per week. Eighty-three percent of subjects reported that they had a primary care physician.

The body weight trajectories of this former NFL player population across the 4 time points assessed (high school [205.1 (35.5) pounds], college [228.4 (39.6) pounds], professional career [239.6 (42.0) pounds], and current weight at the time of survey completion [245.5 (45.9) pounds]) are presented for the total cohort (Figure 2A) and divided by field position (Figure 2B). For the total cohort, there were

Table 1 Definitions of Clinical Afflictions

Clinical Affliction	Definition

Cardiovascular disease	≥ 1 of the following conditions:
	  - Prior myocardial infarction
	  - Prior stroke
	  - Prior coronary revascularization intervention (bypass surgery, angioplasty, or stent)

Cardiometabolic disease	Prior or current prescription of medication for ≥ 2 of the following:
	  - Hypertension
	  - Hyperlipidemia
	  - Diabetes mellitus

Sleep apnea	Clinician-generated diagnosis of sleep apnea
Neurocognitive impairment	Clinician-generated diagnosis of dementia or chronic traumatic encephalopathy OR Prior or current prescription of medication to treat memory loss
Chronic pain	Prior or current prescription of medication for pain AND Ongoing daily use of pain medication at time of survey response

statistically significant increases in weight across each of the 3 time intervals assessed: high school to college (Δ=23.3 [18.2] pounds; $P \le .0001$), college to professional career (Δ=11.3 [13.3] pounds; $P \le .0001$), and professional career to weight at time of survey completion (Δ=5.9 [35.0] pounds; $P \le .001$). Similarly, there were significant increases in weight across each of the intracareer time points for both linemen and nonlinemen (P value for trend <.0001 for both groups). The self-reported prevalence of each clinical affliction, stratified by field position, is shown in Figure 2C. Chronic pain was the most common affliction, affecting approximately 28% of the study population, followed by cardiometabolic disease (25%), sleep apnea (22%), neurocognitive impairment (17%), and cardiovascular disease (9%). Affliction prevalence rates were similar between field position subgroups with the exception of sleep apnea and chronic pain, which were more common among linemen.

Odds ratios (ORs) per 10-pound weight gain for the presence of each clinical affliction, as derived from the models incorporating age and ethnicity (model 1), football exposure characteristics (model 2), and lifestyle characteristics (model 3), are shown in Table 3. Within model 2, weight gain from high school to college had significant associations with the presence of later-life cardiometabolic disease (OR 1.08; 95% CI, 1.01-1.15), chronic pain (OR 1.09; 95% CI, 1.03-1.16), and sleep apnea (OR 1.13; 95% CI, 1.07-1.21), all of which were independent of weight changes in the college to professional period. In contrast, subsequent weight gain from college to professional football playing weight had significant associations with later-life cardiovascular disease (OR 1.11; 95% CI, 1.01-1.22), neurocognitive impairment (OR 1.11; 95% CI, 1.03-1.20), and sleep apnea (OR 1.19; 95% CI, 1.11-1.29), with each being independent of weight gained during the prior high school to college period. The associations between this early-life weight gain and future clinical afflictions retained

statistical significance in a model incorporating postfootball weight gain and key lifestyle variables, including habitual exercise, smoking, and alcohol use (model 3). Stratified analyses by field position (linemen vs nonlinemen) did not appreciably change results but led to some anticipated loss of statistical significance commensurate with loss of power. Similarly, statistical testing for effect modification did not suggest differential impact of field position.

DISCUSSION

This study, designed to examine associations between weight gain and health afflictions among former professional American-style football athletes, generated the following key findings. First, this athletic population is characterized by significant weight gain beginning early in life and continuing through professional football participation well into retirement, with an average overall weight increase of approximately 40 pounds (18.1 kg). Importantly, most of this weight gain occurred during and not after football participation, and this trajectory was not confined to men playing at linemen field positions but was of similar magnitude among both field position subgroups. Second, the prevalence of self-reported health afflictions ranged from 9% for established cardiovascular disease to 28% for chronic pain. Third, weight gain during periods of active football participation, from the high school to college and from the college to professional career period, was strongly and independently associated with the risk of later-life health afflictions after adjustment for metrics defining football exposure, postcareer weight gain, and numerous postfootball lifestyle variables. This observation, addressing the central hypothesis of this study, establishes early-life weight gain among football athletes as a novel risk factor for later-life disease.

A substantial body of literature derived from general population studies demonstrates that early-life weight gain and obesity predict adverse health characteristics, including

Table 2 Demographics and Respondent Characteristics*	
	Former NFL Players (n = 3506)
Demographics	
Age (mean, SD)	52.8 (14.2)
Race/Ethnicity	
Black/African American	1255 (36)
White	2079 (60)
Other	129 (4)
Height (in.) (mean, SD)	74.3 (2.5)
Weight at time of survey (lb) (mean, SD)	245.5 (45.9)
BMI at time of survey (mean, SD)	32.2 (4.9)
Football history	
Age of first football (mean, SD)	11.7 (3.1)
Duration of professional career (mean, SD)	6.8 (3.7)
Position	
Linemen	1270 (36)
Nonlinemen	2236 (64)
Decade of retirement	
1960-1969	247 (7)
1970-1979	655 (19)
1980-1989	789 (23)
1990-1999	606 (17)
2000-2009	760 (22)
2010-2016	414 (12)
Lifestyle factors	
Smoking	
Never	2889 (83)
Past	476 (14)
Current	110 (3)
Alcohol use	
None	1099 (32)
1-7 drinks/wk	1164 (34)
8-14 drinks/wk	470 (14)
>15 drinks/wk	730 (21)
Current exercise	
None	385 (11)
1-2 days/wk	844 (25)
3-4 days/wk	1346 (39)
≥ 5 d/wk	846 (25)
Regular visits with a primary care physician	2881 (83)

BMI = body mass index; NFL = National Football League; SD = standard deviation.

*Values are reported as number (%) unless otherwise specified.

maladaptive cardiac remodeling,[21] atherosclerosis,[22] cardiometabolic disease,[23] diminished quality of life,[24] and overall mortality.[25] Numerous causal mechanisms, including insulin resistance,[26] chronic inflammation,[27] and cumulative exposure to other incompletely understood consequences of obesity,[28, 29] have been proposed. Among elite football athletes, data documenting the relationships between early-life body habitus and later-life health outcomes are comparatively sparse. Obesity is common among high school,[30-32] college,[33] and professional football players,[9] and has been associated with clinical afflictions including cardiometabolic disease and sleep-disordered breathing among active[34] and retired players.[3] Studies of active football players have shown that larger players are at

higher risk for the development of hypertension and maladaptive cardiac remodeling.[19, 20, 35-37] Finally, recent data from Trexler et al[38] demonstrate significant associations between postcareer body mass index changes and phenotypes including coronary heart disease, diabetes, and hypertension. Prior to the current study, however, the impact on subsequent health status of weight gain *during* football participation has not been rigorously examined. Our data now demonstrate strong associations between intracareer weight gain and later-life health afflictions that are independent of postcareer weight gain and other potentially contributory football and lifestyle-related exposures.

The weight gain reported during early adulthood among this elite American-style football cohort is of a similar magnitude to that observed in studies of ethnically similar nonathletic populations.[39] Our data also suggest that former elite-level football athletes are a broadly afflicted group with a high prevalence of adverse health conditions at a relatively young age. Although comparison of the affliction rates observed in this study to those reported in the general public is imperfect, it is noteworthy that the former football athletes appear to have rates of cardiovascular[40] and cardiometabolic disease[41] similar to the general US population. This observation suggests that the cardiovascular health protective effects of routine physical exercise during youth may be offset by the concomitant weight gain among football athletes. In contrast, sleep apnea,[42] chronic pain,[43, 44] and neurocognitive impairment[45] appear substantially more common among former football athletes than among the general public. Although the mechanistic underpinnings of these observations remain speculative, it is probable that weight gain among elite football athletes leads to future clinical affliction via synergistic contributions from the fundamental pathobiology of obesity coupled with body weight−related factors that dictate the nature of the football experience. Findings from this study underscore the need for future work examining how body habitus dictates the inherent physiology of football participation and how individual clinical afflictions impact the presence or severity of other afflictions in this population.

The primary finding from this study, that football-associated weight gain predicts subsequent health, has important clinical implications. Weight gain among aspiring elite football athletes is often a deliberate strategy to improve performance.[46, 47] Although this common practice may have merits, football athletes and the clinicians who care for them deserve a comprehensive data-driven understanding of this strategy that includes a balanced appraisal of risks and benefits. This information represents an essential component of the informed decision-making process that should ultimately include football athletes and the stakeholders who influence their health and performance decisions. It is beyond the scope of our data to comment on whether deliberate football-associated weight gain should be discouraged; however, it seems prudent to provide aspiring football athletes with the full complement of information regarding its potential health impacts. To what degree targeted postcareer weight loss might mitigate the adverse effects of antecedent football-associated weight
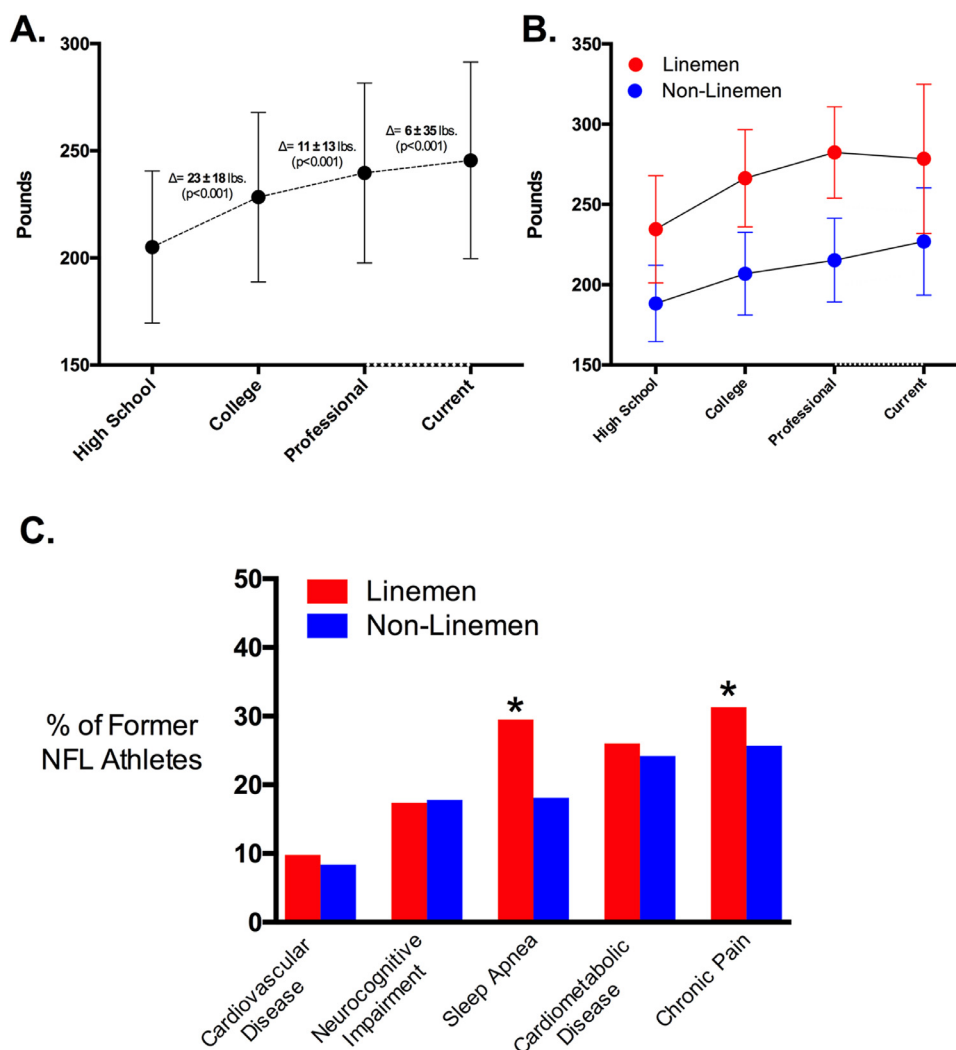
Figure 2 Weight trajectories and prevalence of clinical afflictions among former National Football League players. Panel **A** shows mean weights with standard deviation for all former players during high school, college, and professional career and at the time of survey response. The *P* value for the trend was <.0001. Panel **B** shows weight trajectory data with standard deviations segmented by field position (*P* value for the trend for both linemen and nonlinemen was <.0001). Panel **C** shows prevalence at time of survey response of each of the 5 defined outcomes again stratified by field position. *Statistically significant (*P* < .05) difference between prevalence among former linemen and nonlinemen.

gain remains unknown and represents an essential area for future research.

Our data and their inherent limitations should be interpreted in the context of the study design. First, all data come from health survey responses and thus are subject to the limitations of self-reported data. However, similar data in different populations suggest broadly accurate reporting on the prevalence of chronic health conditions,[48] and former NFL players are likely to be accurate in their weight recollections, given the frequency of measurement and emphasis placed on weight in football training and competition. Second, potential selection bias is an additional important consideration. It is possible that respondents to our survey (representing approximately

28% of eligible former players) may have different weight trajectories and different clinical affliction profiles compared with nonresponders. Third, we urge caution in generalizing our findings to other populations, including nonathletes and athletes from other sporting disciplines, because football athletes may experience unique health risks such as frequent head trauma and musculoskeletal injuries. In addition, football athletes may gain weight with different body composition, characterized by a higher percentage of lean muscle mass, in comparison to that seen in other cohorts.[49] Finally, weight and affliction data contained in this study were assessed at the single time point of survey completion. We acknowledge that we cannot therefore determine causal relationships

Table 3   Odds Ratios for Associations of Intracareer Weight Gain with Later-Life Clinical Afflictions*

	High School to College OR (95% CI)	College to Professional OR (95% CI)
Model 1		
Cardiovascular disease	1.05 (0.96, 1.14)	1.09 (1.00, 1.19)[†]
Cardiometabolic disease	1.04 (0.99, 1.10)	1.03 (0.97, 1.10)
Sleep apnea	1.11 (1.05, 1.17)[†]	1.18 (1.11, 1.27)[†]
Neurocognitive impairment	0.95 (0.90, 1.01)	1.13 (1.05, 1.21)[†]
Chronic pain	1.09 (1.04, 1.15)[†]	1.07 (1.00, 1.14)[†]
Model 2		
Cardiovascular disease	1.06 (0.96, 1.17)	1.11 (1.01, 1.22)[†]
Cardiometabolic disease	1.08 (1.01, 1.15)[†]	1.07 (0.99, 1.15)
Sleep apnea	1.13 (1.07, 1.21)[†]	1.19 (1.11, 1.29)[†]
Neurocognitive impairment	0.96 (0.90, 1.03)	1.11 (1.03, 1.20)[†]
Chronic pain	1.09 (1.03, 1.16)[†]	1.05 (0.98, 1.13)
Model 3		
Cardiovascular disease	1.07 (0.96, 1.19)	1.14 (1.03, 1.26)[†]
Cardiometabolic disease	1.09 (1.02, 1.17)[†]	1.11 (1.03, 1.20)[†]
Sleep apnea	1.15 (1.08, 1.23)[†]	1.25 (1.16, 1.34)[†]
Neurocognitive impairment	0.94 (0.87, 1.01)	1.13 (1.04, 1.22)[†]
Chronic pain	1.09 (1.03, 1.16)[†]	1.06 (0.99, 1.14)

CI = confidence interval; OR = odds ratio.

*Odds ratios are per 10-lb weight gain compared with no change in weight. Model 1 includes weight change from high school to college, weight change from college to professional, high school weight, age at survey completion, and self-identified race. Model 2 includes all covariates from model 1 with the addition of age of first competitive football participation, number of seasons played in the National Football League, and field position. Model 3 includes all covariates from model 2 with addition of postcareer weight gain (professional to highest retirement weight), smoking status, habitual exercise, and alcohol use.

[†]Statistical significance at $P \leq .05$.

between weight trajectories and clinical affliction, for which longitudinal, prospective data will be required.

In summary, we show independent associations in former NFL players between early-adulthood weight gain during periods of football participation and later-life adverse clinical afflictions across a range of health domains. This association appears particularly robust for weight gained in the college to professional transition and persists despite adjustment for demographic factors, football exposure, and postcareer lifestyle variables and weight gain. These findings suggest that football-associated weight gain occurring in early-adulthood has important health implications that manifest in the postcareer years. Further research, ideally involving prospective data capture coupled with careful clinical phenotyping, is required to explore mechanisms underlying the link between football-associated weight gain and later-life clinical affliction.

ACKNOWLEDGMENTS

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