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Weight Gain and Health Affliction Among Former National Football League Players

Running Head: Football-Associated Weight Gain and Health

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Abstract

Background: Professional American-style football players are among the largest athletes across contemporary sporting disciplines, and weight gain during the years of football participation is common. At present, 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 health afflictions common in this population (cardiovascular disease, cardiometabolic disease, neurocognitive impairment, sleep apnea, and chronic pain).

Methods: A comprehensive health survey was distributed to former National Football League (NFL) players. Former players reported body weight at 4 key 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 and after football participation with health affliction.

Results: In this cohort of former NFL players (n=3,506, age 53±14 years), mean total weight increase from high school to time of survey response was 40±36 pounds, with the majority of weight gain occurring during and not after football participation. The prevalence of self-reported health afflictions ranged from 9% for cardiovascular disease to 28% for chronic pain. Weight gain during periods of active football participation (high school to college and college to professional) was independently associated with risk of multiple later life health afflictions in models adjusted for football exposure, post-career lifestyle variables, and post-career weight gain.

C**onclusions**: 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.

Word Count = 277

Introduction

The impact of participation in American-style football on health and longevity remains 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 predispose to these forms of disease remain uncertain.[5]

At both collegiate and professional levels, American-style football athletes are among the largest athletes across all contemporary sporting disciplines. Over 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] While 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 as weight gain and corollary body size among football athletes may carry different prognostic implications. At present, lifetime body mass trajectory among elite football athletes, with emphasis on quantifying weight gain during the period of football participation, and its association with post-career pathology remain largely unexplored.

We hypothesized that body size among former NFL players, specifically weight gain that occurred during their progression from the high school to the collegiate to the 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 utilized 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 five 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 public online sources (NFL Pro-Reference) were used to identify living former NFL players whose career 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 (for online surveys) or Scantron (for paper surveys). This study was approved by the Institutional Review Board of Beth Israel Deaconess Medical Center, an affiliate of Harvard Medical School.

Respondent Characteristics and Covariates

A total of 3,506 of 12,357 (28.4%) contacted former players completed the survey by the time of this analysis and thus comprise 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 collegiate football participation, 3) maximal weight during professional football participation, and 4) at the time of survey completion (i.e. current weight), as well as maximum post-retirement weight. Body mass index (BMI) was calculated as body weight in kilograms divided by height in meters squared 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 was classified based on

responses to question regarding number of days of exercise in an average week. To assess engagement with the healthcare 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 non-linemen, 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 non-lineman 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, angioplasty, 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 five 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, two weight change time periods were selected for primary analysis: high school weight to college weight (i.e. high school-to-college) and college weight to professional weight (i.e. college-to-pro). 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 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 post-career weight gain (professional weight to maximum retirement weight) and additional lifestyle factors including smoking status, habitual exercise, and alcohol use. Maximum retirement weight was chosen for inclusion to maximally account for post-career weight gain. Effect modification by field position (linemen vs. non-linemen) was assessed by inclusion of an interaction term between field position and weight gain. Prevalence of the clinical afflictions among linemen and non-linemen was compared using chi-squared test. Statistical significance was defined by the 95% level of confidence ($P<0.05$). All analyses were done using SAS Version 9.0.

Results

Characteristics of survey respondents are summarized in **Table 2**. The average 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. The majority of respondents started playing competitive football in their pre-teen years (average age = 11.7 years). Approximately one third of respondents played a lineman position, and the average professional career spanned approximately 7 seasons. The majority of 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 over 20% consuming more than 15 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. 83% percent of patients reported that they had a primary care physician.

The body weight trajectories of this former NFL player population across the four time points assessed [high school (205.1±35.5 lbs.), college (228.4±39.6 lbs.), professional career (239.6±42.0 lbs.), and current weight at the time of survey completion (245.5±45.9 lbs.)] are presented for the total cohort

(**Figure 2A**) and divided by field position (**Figure 2B**). For the total cohort, there were statistically significant increases in weight across each of the 3 time intervals assessed: high school to college (Δ=23.3±18.2 lbs, p=<0.0001), college to professional career (Δ=11.3±13.3 lbs, p=<0.0001), and professional career to weight at time of the survey completion (Δ=5.9±35.0 lbs, p=<0.001). Similarly, there were significant increases in weight across each of the intra-career time points for both linemen and non-linemen (p-value for trend <0.0001 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 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 (1.01,1.15)], chronic pain [OR =1.09 (1.03,1.16)], and sleep apnea [OR =1.13 (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 (1.01, 1.22)], neurocognitive impairment [OR =1.11 (1.03, 1.20)], and sleep apnea [OR =1.19 (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 post-football weight gain and key lifestyle variables including habitual exercise, smoking, and alcohol use (Model 3). Stratified analyses by field position (linemen vs. non-linemen) 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. Importantly, the vast majority 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 high school to college and from college to the professional career period, was strongly and independently associated with the risk of later-life health afflictions after adjustment for metrics defining football exposure, post-career weight gain, and numerous post-football 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 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] collegiate,[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 and colleagues demonstrate significant associations between post-career BMI changes and phenotypes including coronary heart disease, diabetes, and hypertension.[38] 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 intra-career weight gain and later-life health afflictions that are independent of post-career 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 non-athletic 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. While 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 U.S. 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. While 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] While this common practice may have merits, football athletes and the clinicians that 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 that influence their health and performance decisions. While it is beyond the scope of our data to comment on whether deliberate football-associated weight gain should be discouraged, it seems prudent to provide aspiring football athletes with the full compliment of information regarding its potential health impacts. To what degree targeted post-career weight loss might mitigate the adverse effects of antecedent football-associated weight 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 as compared to non-responders. Third, we urge caution in generalizing our findings to other populations including non-athletes and athletes from other sporting disciplines, as 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 therefor determine causal relationships 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 post-career 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 post-career 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.

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All authors participated in the research presented in this manuscript, and all authors have approved this manuscript.

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Table 1: Definitions of Clinical Afflictions

Clinical Affliction	Definition
Cardiovascular Disease	At least 1 out 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

Table 2. Demographics and Respondent Characteristics

	Former NFL Players (n=3,506)
Demographics	
Age (mean, SD)	52.8 (14.2)
Race / Ethnicity	
Black / African-American	1,255 (36)
White	2,079 (60)
Other	129 (4)
Height (inches) (mean, SD)	74.3 (2.5)
Weight at Time of Survey (pounds) (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	1,270 (36)
Non-Linemen	2,236 (64)
Decade of Retirement	
1960-69	247 (7)
1970-79	655 (19)
1980-89	789 (23)
1990-99	606 (17)
2000-2009	760 (22)
2010-2016	414 (12)
Lifestyle Factors	
Smoking	
Never	2,889 (83)
Past	476 (14)
Current	110 (3)
Alcohol Use	
None	1,099 (32)
1-7 Drinks per Week	1,164 (34)
8-14 Drinks per Week	470 (14)
15+ Drinks per Week	730 (21)
Current Exercise	
None	385 (11)
1-2 days/week	844 (25)
3-4 days/week	1,346 (39)
5 or more days/week	846 (25)
Regular Visits with a Primary Care Physician	2,881 (83)

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

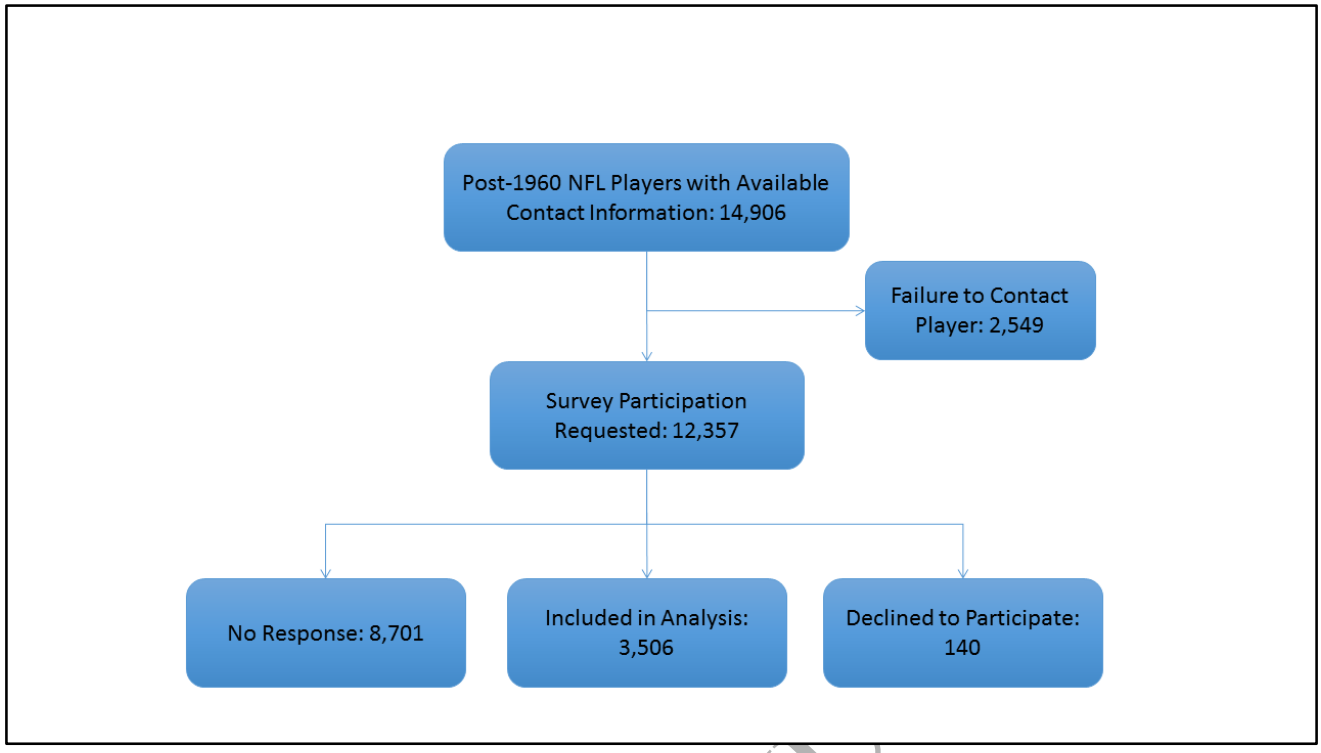
Table 3. Odds Ratios for Associations of Intra-Career Weight Gain with Later Life Clinical Afflictions

	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)

Odds ratios are per 10 pounds weight gain as compared to no change in weight; * indicates statistical significance at $p \leq 0.05$.

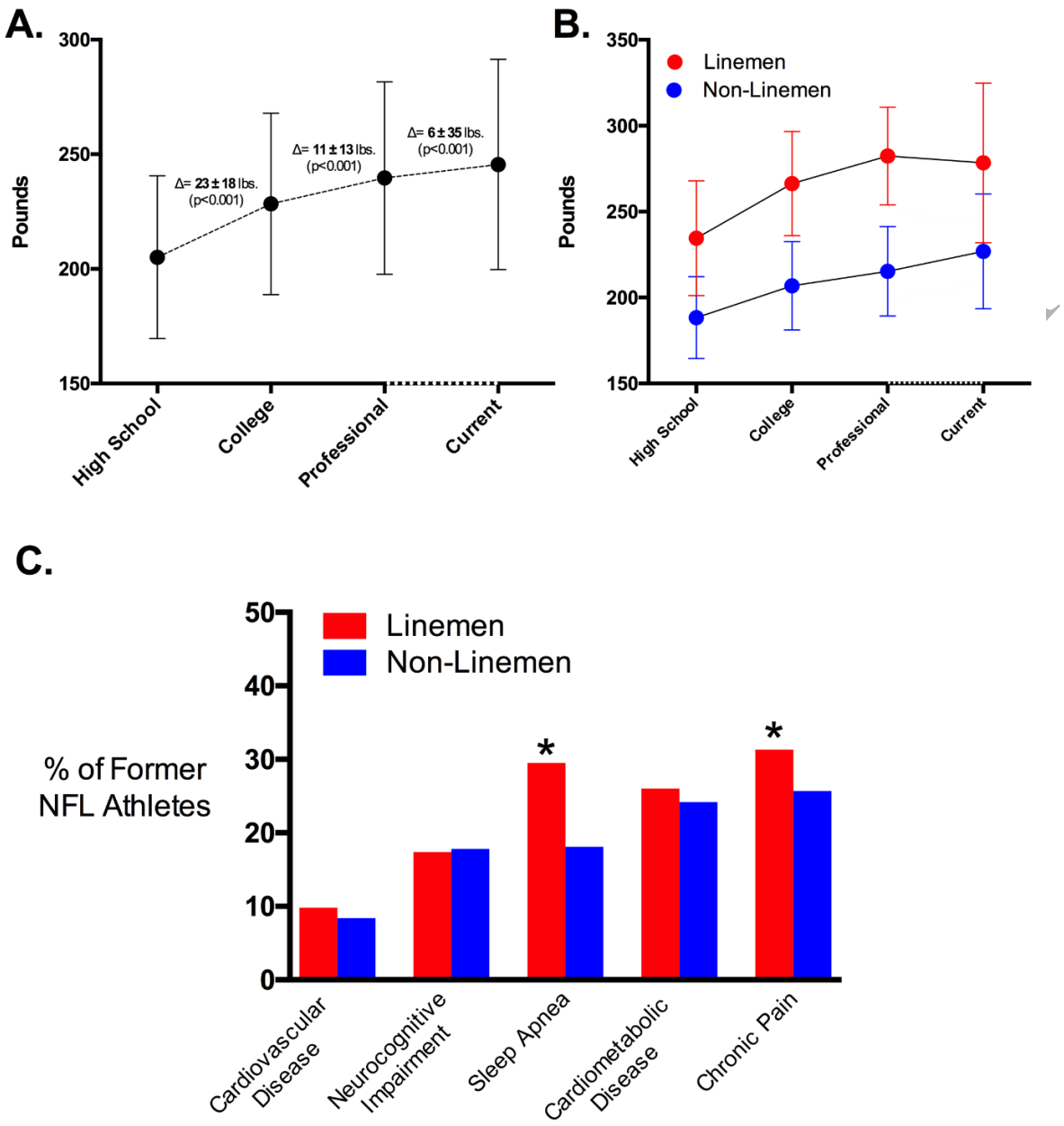
Model 1 includes weight change from high school to college, weight change from college to professional, high school weight, age at survey completion, and self-identified race. Model 2 includes all covariates from Model 1 with the addition of age of first competitive football participation, number of seasons played in the NFL, and field position. Model 3 includes all covariates from Model 2 with addition of post-career weight gain (professional to maximum retirement weight), smoking status, habitual exercise, and alcohol use.

Figure 1. Eligible Former NFL Players and Survey Response



The above flowchart shows eligible former National Football League players and response rates to the study survey tool.

Figure 2: Weight Trajectories and Prevalence of Clinical Afflictions Among Former NFL Athletes



* indicates statistically significant ($p<0.05$) difference between prevalence among former linemen and non-linemen.

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. P-values for trend was <0.0001. Panel B shows weight trajectory data with standard deviations segmented by field position (p-value for trend for

both linemen and non-linemen <0.0001). Panel C shows prevalence at time of survey response of each of the 5 defined outcomes again stratified by field position.

Clinical Significance

Former professional American-style football athletes typically gain substantial weight from high school through middle-age, with the majority of weight gain occurring years of football participation.

This early-life weight gain is associated with increased prevalence during middle-age of multiple health afflictions including cardiovascular disease, cardiometabolic disease, sleep apnea, neurocognitive impairment, and chronic pain.

These findings raise important questions about the central role of targeted, football-associated weight gain in this population.