Body Mass Index Versus Body Fat Percentage in Prospective National Football League Athletes: Overestimation of Obesity Rate in Athletes at the National Football League Scouting Combine

Matthew T. Provencher,[1,2] Jorge Chahla,[1] George Sanchez,[1] Mark E. Cinque,[1] Nicholas I. Kennedy,[1] Jim Whalen,[3] Mark D. Price,[4] Gilbert Moatshe,[1,5,6] and Robert F. LaPrade[1,2]

[1]Steadman Philippon Research Institute, Vail, Colorado; [2]Steadman Clinic, Vail, Colorado; [3]New England Patriots, Foxborough, Massachusetts; [4]Massachusetts General Hospital, Boston, Massachusetts; [5]Oslo University Hospital and University of Oslo, Oslo, Norway; and [6]OSTRC, Norwegian School of Sports Sciences, Oslo, Norway

Abstract

Provencher, MT, Chahla, J, Sanchez, G, Cinque, ME, Kennedy, NI, Whalen, J, Price, MD, Moatshe, G, and LaPrade, RF. Body mass index versus body fat percentage in prospective national football league athletes: overestimation of obesity rate in athletes at the national football league scouting combine. *J Strength Cond Res* 32(4): 1013–1019, 2018–Obesity has been previously noted as a major issue in the National Football League (NFL), where it has been shown that 97% of all players demonstrate a body mass index (BMI) of ≥25.0 with a reported obesity rate of 56% (BMI ≥ 30.0). However, BMI does not take into account body composition by mass, and may overestimate prevalence of obesity. The purposes of this study were (a) to determine the validity of BMI as a measure of body fat percentage and obesity in athletes at the NFL Combine, (b) to define the obesity rate based on body fat percentage compared with BMI, and (c) to determine the relationship between draft status and body composition. It was hypothesized that the rate of obesity, as measured by air displacement plethysmography (ADP), would be less than the rate of obesity as measured using BMI. Athletes who competed at the 2010 through 2016 NFL Combines were included in this study. Air displacement plethysmograph testing at the Combine was performed through BOD POD Body Composition Tracking System with collection of the following metrics: body fat percentage (%), and compared with BMI based on weight and height. In addition, the metrics were evaluated for differences over the 7-year study period to determine temporal changes and to determine draft status based on position relative to BOD POD calculations. A total of 1,958 NFL Combine participants completed ADP body composition testing. Based on BMI (≥30.0), the obesity rate was 53.4% versus an 8.9% obesity rate when using ADP. Drafted players demonstrated a significantly lower body fat percentage than undrafted players ($p \leq 0.05$), with the exception of quarterbacks and running backs. All 8 positions of play, with the exception of defensive linemen, demonstrated a decrease in body fat percentage between 2010 and 2017. However, total body mass by position of play remained relatively constant with no significant change noted in any position. In conclusion, the obesity rate in prospective athletes at the NFL Combine was overestimated when calculated based on the BMI. Body fat percentage was more valid for determining an NFL player candidate's true body composition. Drafted players demonstrated a significantly lower body fat percentage in 6 of 8 positions compared with undrafted players. This is important to recognize for a strength and conditioning professional to use the correct metric when evaluating NFL players who could have been erroneously categorized in the obese population by their BMI. Furthermore, a higher percentage of fat translates to lower chances of becoming drafted.

Key Words NFL combine, performance, draft status, body composition

Introduction

Obesity is a prevalent health concern with a significant rise in the number of obese adults in the United States (12). By 2030, the total number of obese adults in the United States is projected to increase by 65 million with an associated increase in medical costs of $48–66 billion/year for treatment of preventable

Address correspondence to Dr. Matthew T. Provencher, mmpro@mac.com.

32(4)/1013–1019

Journal of Strength and Conditioning Research

Table 1. Demographics, BMI, and BF% by position of play.*

	Total number of players	Percent drafted, %	Mean BMI (range)	Percent of obese players by BMI, %	Mean BF % (range, %)	Percent of obese players by BF%	Mean total body Mass (range), kg
Quarterbacks	108	70/108 (64.8)	28.0 (25.4–30.2)	2/108 (1.9)	14.6 (5.5–22.7)	0/108 (0)	101.7 (85.2–115.9)
Running backs	199	117/199 (58.8)	30.6 (24.2–45.1)	130/199 (65.3)	11.2 (3.3–20.8)	0/199 (0)	98.3 (76.5–123.4)
Wide receivers	262	156/262 (59.5)	26.9 (23.3–30.6)	2/262 (0.8)	8.8 (3.2–19.4)	0/262 (0)	91.7 (67.7–109.3)
Tight ends	105	67/105 (63.8)	30.4 (26.5–33.6)	67/105 (63.8)	13.8 (6.3–20.4)	0/105 (0)	114.2 (101.9–123.0)
Offensive Linemen	312	213/312 (68.2)	37.5 (33.4–45.9)	312/312 (100)	23.7 (13.8–34.7)	118/312 (37.8)	141.8 (127.0–163.5)
Linebackers	212	151/212 (71.2)	31.3 (27.1–36.0)	179/212 (84.4)	13.4 (4.0–21.7)	0/212 (0)	109.3 (92.1–123.7)
Defensive linemen	343	248/343 (72.3)	35.5 (27.5–44.7)	333/343 (97.1)	19.3 (3.8–31.5)	55/343 (16.0)	129.4 (100.4–167.2)
Defensive backs	349	249/349 (71.3)	27.4 (22.5–32.5)	13/349 (3.7)	9.3 (3.2–19.4)	0/349 (0)	90.3 (76.6–104.5)
Kickers	62	18/62 (29.0)	26.8 (23.3–31.0)	3/62 (4.8)	14.5 (3.8–24.6)	0/62 (0)	93.1 (74.7–112.4)
Long snappers	6	1/6 (16.7)	31.4 (29.7–33.3)	5/6 (83.3)	22.1 (18.7–26.5)	1/6 (16.7)	112.7 (107.5–117.5)
All	1958	1,290/1,958 (65.9)	31.3 (22.5–45.9)	1,046/1,958 (53.4)	14.7 (3.2–34.7)	174/1,958 (8.9)	110.5 (67.6–167.2)

*BMI = body mass index; BF% = body fat percentage.

diseases resulting from obesity (14). It has also been noted as a major issue in the National Football League (NFL), where it has been reported that 97% of all players demonstrate a body mass index (BMI) of ≥25.0 with a reported obesity rate of 56% (BMI ≥ 30.0) (6).

Previous reports describing the widespread increase in incidence of obesity in the United States and worldwide are largely based on the use of BMI to indirectly indicate the level of adiposity (2,13,16). However, the incidence of obesity may be overestimated, given that fat mass and fat-free mass are not differentiated through BMI (9,15). Anzell et al. reported that over a 70-year period (1942–2011) that there has been a significant increase in body weight and percent body fat for college football players, with no significant change in body height, suggesting that the BMI might not be a reliable measure to evaluate these players (1). By contrast, body composition may be fully evaluated through use of an alternative, more sophisticated technique (8). Air displacement plethysmography (ADP) estimates body composition, including body fat percentage, through measurements of body density (10). Air displacement plethysmography has been validated as an accurate tool to assess body fat percentage (10).

With an associated greater risk of diabetes (7), coronary heart disease (12), and cancer (13) due to obesity, NFL football players may be inappropriately characterized as an at-risk patient population for these preventable diseases (3,14). Therefore, the purposes of this study were to (a) determine the validity of BMI as a measure of body fat percentage and obesity in athletes at the NFL Combine, (b) to define the obesity rate based on body fat percentage compared with BMI, and (c) to determine the relationship between draft status and body composition.

Methods

Experimental Approach to the Problem

This study was a retrospective review of all collegiate athletes who participated in the annual NFL Scouting Combine between 2010 and 2016. Each participant of the NFL Scouting Combine underwent a comprehensive medical and physical examination, comprising history, physical examination, and imaging studies completed at the Combine. As part of each examination, the participant also undergoes ADP testing. All ADP testing at the Combine from 2010 to 2016 was completed using BOD POD Body Composition Tracking System (COSMED USA, Inc.,

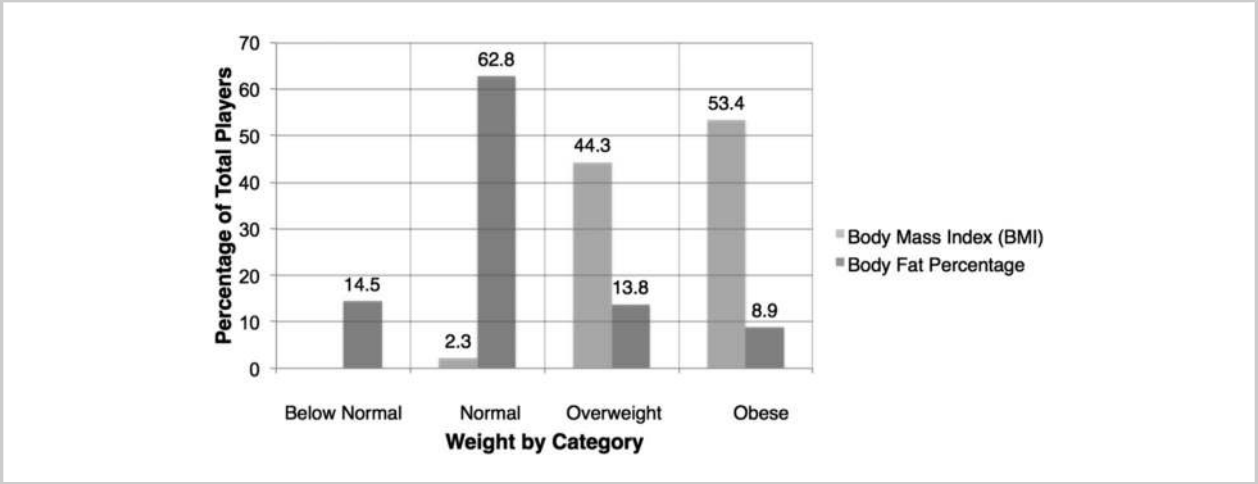

Figure 1. Categorization of weight based on body mass index and body fat percentage in prospective NFL players. Percentages of prospective NFL players in each BMI and body fat percentage category. Body mass index was calculated as weight in kilograms divided by square of height in meters ($kg \cdot m^{-2}$) from values recorded at the annual NFL scouting combine. Body fat percentage values based on air displacement plethysmography were collected using BOD POD body composition tracking system (COSMED USA, Inc., Concord, CA, USA) at The combine. NFL = National Football League; BMI = body mass index.

Concord, CA, USA) with collection of the following metrics: body fat percentage (%), fat mass (kg), fat free mass (kg), total body mass (kg), and estimated resting metabolic rate ($kcal \cdot d^{-1}$). Body measurement variables demonstrated a normal distribution for each playing position. Therefore, parametric statistical tools were used. Mean ($\pm SD$) were reported to summarize measurements. To test the study hypotheses, Welch's *t*-tests were used to compare body measurements between drafted and undrafted players. Pearson's correlations were used to test for linear trends in measurements by position across the 2010 to 2016 period.

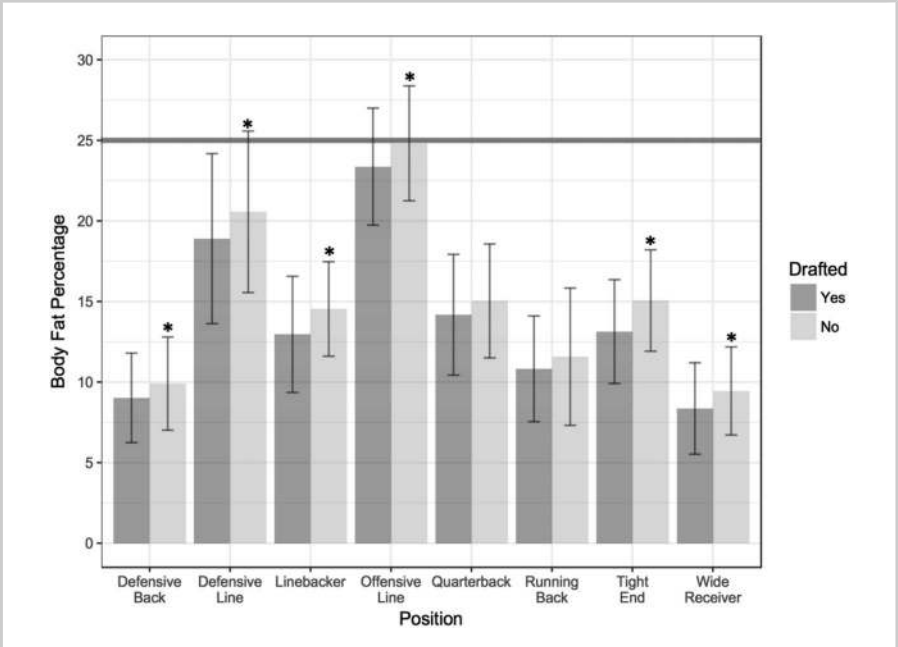

Figure 2. Difference in mean body fat percentage between drafted and undrafted prospective NFL players. mean body fat percentage collected using BOD POD body composition tracking system (COSMED USA, Inc., Concord, CA, USA) in drafted and undrafted players at each of the 8 analyzed positions of play from the 2010 to 2016 annual NFL Scouting Combine. The red line denotes the obesity cutoff for body fat percentage (i.e., ≥25.0%), whereas the dotted black line denotes the mean body fat percentage for all 1,958 combine participants. Statistically significant differences ($p \leq 0.05$) between drafted and undrafted players are noted with a star (*). NFL = National Football League.

Subjects

Subjects were between 20-24 years old. Approval for this study was obtained from Massachusetts General Hospital at (IRB#: 2015P002224/MGH) as well as the NFL Physicians Society Research Committee. Each participant of the NFL Scouting Combine underwent a comprehensive medical and physical examination comprising history, physical examination, and imaging studies completed at the Combine. Subjects provided written consent.

Procedures

As part of each examination, the participant also undergoes ADP testing. All ADP testing at the Combine from 2010 to

Table 2. Body fat percentage (%) reported as mean (standard deviation) by position for the drafted and undrafted players.*

	Body fat percentage (SD) for drafted combine athletes (%)	Body fat percentage (SD) for undrafted combine athletes (%)
Offensive line	23.3 (3.7)	24.8 (3.6)
Quarterback	14.3 (3.7)	15.2 (3.3)
Running back	11 (3.4)	11.5 (4.3)
Wide receiver	8.3 (2.8)	9.5 (2.7)
Tight end	13.1 (3.2)	14.9 (3.2)
Defensive line	18.9 (5.3)	20.4 (5.3)
Defensive back	9.1 (2.8)	10.1 (3.1)
Linebacker	13 (3.7)	14.6 (2.9)
Kicker	12.5 (3.5)	15.2 (4.2)

*Reported as mean (*SD*).

2016 was completed using BOD POD Body Composition Tracking System (COSMED USA, Inc., Concord, CA, USA) with collection of the following metrics: body fat percentage (%), fat mass (kg), fat free mass (kg), total body mass (kg), and estimated resting metabolic rate (kcal/day). These body composition data were recorded for participants who completed ADP testing during the annual NFL Combine between 2010 and 2016 with exclusion of the 2015 NFL Combine class because BOD POD Body Composition Tracking System data were unavailable for this year. The physical design and operating principle of this product have been described in detail previously with reliability and validity for body measurements confirmed (4,8,10,11).

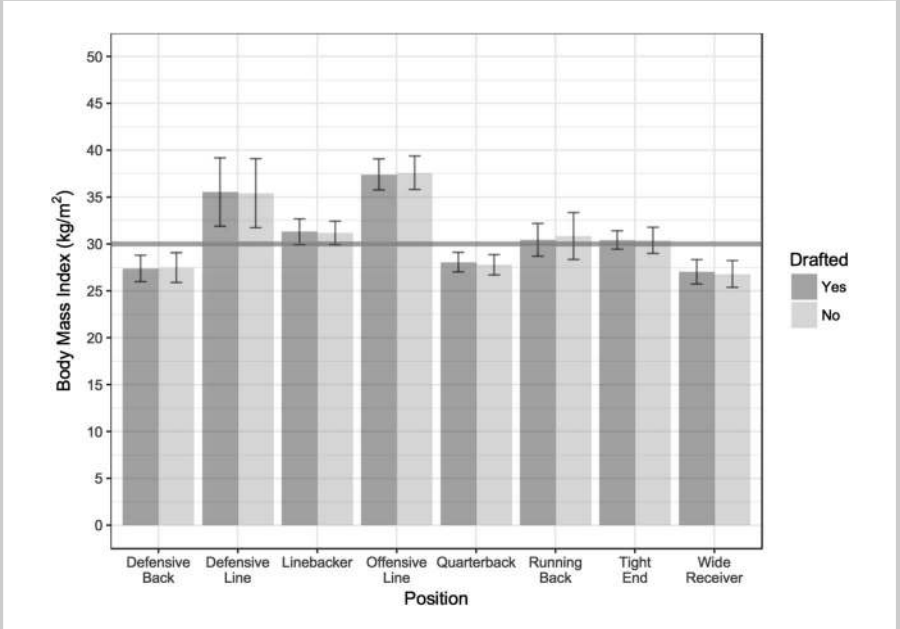

Figure 3. Difference in mean body mass index between drafted and undrafted prospective NFL players. Mean body mass index (BMI) ($kg \cdot m^{-2}$) in drafted and undrafted players at each of the 8 analyzed positions of play from the 2010 to 2016 annual NFL Scouting Combine. The red line denotes the obesity cutoff for BMI (i.e., ≥30.0%), whereas the dotted black line denotes the mean BMI for all 1,958 combine participants. NFL = National Football League; BMI = body mass index.

The height and body mass of each participant were also recorded and used to calculate BMI. Similar to Harp and Hecht (6), BMI was determined through the following equation: body mass in kilograms divided by height in meter squared, or $kg \cdot m^{-2}$. Body mass index was classified according to guidelines supported by the National Institutes of Health and World Health Organization: below normal weight (BMI < 18.5), normal weight (18.5–24.9), overweight (25.0–29.9), and obese (≥30.0). By contrast, categories for body fat percentages were classified according to ranges proposed by Gallagher et al. (5) using dual-energy X-ray absorptiometry and multiple regression analysis on a total of 1,626 adults across 3 sites, with the following ranges for African

Table 3. Mean body fat percentage and mean total body mass by position of play (2010–2016).*

	2010	2011	2012	2013	2014	2016	*p*
Quarterbacks							
Mean body fat percentage	16.2 (4)	12.9 (3.6)	14.2 (3.5)	14.8 (3.6)	13.7 (3.2)	15 (3.7)	0.755
Mean total body mass (kg)	101.1 (5.7)	103.5 (5.9)	100.2 (5.7)	102.1 (3.8)	100.7 (4.8)	102.7 (6.5)	0.801
Running backs							
Mean body fat percentage	12.4 (4.2)	11.3 (3.9)	11.9 (3.3)	11.3 (3.3)	8.9 (3.8)	11.5 (3.1)	0.066
Mean total body mass (kg)	98.7 (8.2)	98.9 (7.9)	97.6 (6.8)	96.7 (7.4)	97.6 (8.3)	100.6 (7.1)	0.562
Wide receivers							
Mean body fat percentage	10.1 (2.3)	9.2 (2.4)	9.7 (3.1)	9.3 (2.6)	6.3 (2.5)	8.4 (2.5)	***<0.001***
Mean total body mass (kg)	91.2 (7.3)	91.9 (6.4)	91.8 (7.3)	92.5 (6.7)	90.6 (7.7)	92.6 (5.1)	0.585
Tight Ends							
Mean body fat percentage	15.1 (2.9)	14.7 (3.1)	14.1 (2.8)	13.3 (3.6)	12.3 (3.7)	14 (3)	0.052
Mean total body mass (kg)	115 (4.6)	114.6 (3.6)	112.1 (3.3)	114.2 (4.5)	115.7 (5.6)	112.8 (3.7)	0.528
Offensive linemen							
Mean Body Fat Percentage	25 (3.5)	24.9 (3.5)	24.4 (3.5)	23.3 (3.7)	21.7 (3.8)	23.5 (3)	***<0.001***
Mean total body mass (kg)	141.8 (4.3)	142 (5.4)	142.4 (5.2)	142 (5.6)	141.8 (5)	140.9 (4.7)	0.221
Linebackers							
Mean body fat percentage	13.5 (3.8)	14.5 (2.8)	13.7 (3.2)	14 (2.8)	11.8 (3.4)	13.2 (4.2)	0.082
Mean total body mass (kg)	108.9 (4.8)	109.5 (3.7)	109.8 (4)	109.6 (3.4)	110 (4.2)	108.3 (4.6)	0.625
Defensive linemen							
Mean body fat percentage	18.6 (4.9)	19.6 (5.3)	20.3 (4.6)	18.6 (6.2)	19.1 (5.8)	19.9 (4.7)	0.469
Mean total body mass (kg)	127.5 (12.2)	129.1 (10.8)	130.4 (10.7)	129 (13.9)	130.3 (13.1)	130.2 (10.8)	0.258
Defensive backs							
Mean body fat percentage	9.3 (2.9)	9.9 (3.1)	10 (2.5)	8.9 (2.9)	9 (2.9)	8.7 (2.6)	***0.027***
Mean total body mass (kg)	90.6 (5.8)	90.3 (5.2)	90.2 (5)	90.6 (5.4)	90 (4.3)	89.9 (5.1)	0.442

*x (y) = mean (*SD*).
$p<0.05$ indicated in bold and italics.

Americans and whites were suggested: below normal (body fat percentage <8.0%), normal weight (8.0–19.9%), overweight (20.0–24.9%), and obese (≥25.0%) (5).

Player Position Subanalysis and Draft Status. After compilation of all available body composition measures, participants were organized by the year of NFL Combine and their position of play. All athletes were organized into the following 10 categories for position of play: (a) offensive lineman, (b) quarterback, (c) running back, (d) tight end, (e) wide receiver, (f) defensive lineman, (g) defensive back, (h) linebacker, (i) long snapper, and (j) kicker. Moreover, each player was designated as either drafted or undrafted in his respective NFL Draft. Body composition values were subsequently analyzed by position of play, status as drafted or undrafted, and year of Combine to detect differences and trends in body composition in prospective NFL players. The long snapper and kicker positions were excluded from analysis involving drafted and undrafted players as well as over time (i.e., 2010–2016) given the low total number ($n = 68$) of athletes as well as these positions' exclusive role on special teams, and not specifically for offensive or defensive play.

Statistical Analyses

Body measurement variables demonstrated a normal distribution for each playing position. Therefore, parametric statistical tools were used. Mean ($\pm SD$) were reported to summarize measurements. To test the study hypotheses, Welch's t-tests were used to compare body measurements between drafted and undrafted players. Pearson's correlations were used to test for linear trends in measurements by position across the 2010 to 2016 period. All statistical analyses and graphics were produced using the statistical computing package R, version 3.3.2 (R Development Core Team, Vienna, Austria), and the additional package ggplot2. Statistical significance was achieved if $p \leq 0.05$.

Results

Demographics

A total of 1,977 athletes participated in the annual NFL Scouting Combine between 2010 and 2016. Of these 1,977, 1,958 (99.0%) completed ADP testing. Of the 1,958, 1,290 (65.9%) were drafted in their respective NFL Draft. Of the total 1,958 participants who completed ADP testing, the total number of players at a position ranged from 6 long snappers to 349 defensive backs. For the entire cohort, the mean BMI was 31.3 $kg \cdot m^{-2}$ (SD: 4.5, range: 22.5–45.9), whereas the mean body fat percentage was 14.7% (SD: 6.5, range: 3.2–34.7%).

Air Displacement Plethysmography Versus Body Mass Index Measurement

Six of the 10 positions of play analyzed showed a >50% obesity rate based on BMI. However, the use of body fat percentage revealed no position of play with an obesity rate ≥50% with the highest rate seen in offensive linemen at 37.8%. Moreover, 7 of the 10 positions displayed no obese players according to body fat percentage (Table 1).

Of the 1,958 participants examined, 1,913 (97.7%) were categorized as overweight (25.0–29.9) or obese (≥30.0) according to BMI. However, when using body fat percentage, categorization as overweight or obese was demonstrated in 445 of the 1,958 participants (22.7%). Moreover, based on body fat percentage, 174 of the 1,958 (8.9%) examined athletes were obese, whereas 284 participants (14.5%) were below normal body fat percentage (Figure 1).

Player Position Subanalysis and Draft Status

Across all positions, mean body fat percentage was lower in drafted players than undrafted players. This difference in mean body fat percentage between drafted and undrafted players was significant in 6 of the 8 analyzed positions, excluding the quarterback and running back positions (Figure 2 and Table 2).

In comparison, mean BMI demonstrated very similar values between drafted and undrafted players with no significant difference in all positions analyzed (Figure 3).

All 8 positions of play, with the exception of defensive linemen, demonstrated a decrease in body fat percentage between 2010 and 2016. Of the 8 analyzed positions of play, 3 positions including offensive linemen ($p < 0.001$), wide receivers ($p < 0.001$), and defensive backs ($p \leq 0.05$) demonstrated a significant decrease in body fat percentage. However, total body mass by position of play remained relatively constant from 2010 to 2016 with no significant change noted in any position (Table 3).

Discussion

The most important finding of this study was that for athletes screened at the NFL Combine, the overall obesity rate using ADP testing was 8.9%, whereas an obesity rate of 53.4% was estimated through use of BMI. In addition, players subsequently drafted in their respective NFL Draft demonstrated a significantly lower body fat percentage compared with undrafted athletes. However, drafted and undrafted football players featured similar BMI measures. Altogether, 97.7% of the 1,958 NFL Combine participants were categorized as either overweight or obese based on BMI. The results from this study suggest that athletes at the NFL Combine are inappropriately labeled as overweight and obese due to use of BMI. Therefore, body fat percentage is a more accurate measure for the identification of the obesity rate in this population and other high-level athletes.

We found obesity rates of 53.4% in this study when using the BMI. However, when the body fat percentage was used, the obesity rate was 6 times lower. This could be due to the lack of consideration of the person's bone, muscle, or fat proportions, which is a key factor in these elite athletes. Thus, we confirmed the recommendations of Harp and Hecht (3) who had previously reported an obesity rate of 56% in 2,168 NFL players based on BMI and suggested that body composition measurements were required to identify the source of excess weight.

Across all positions of play, we found that prospective NFL football players subsequently drafted in their respective NFL Draft demonstrated a lower body fat percentage versus undrafted players. This difference between drafted and undrafted players was significant in 6 of the 8 positions of play analyzed. But when BMI was compared between drafted and undrafted players, no significant differences were noted in any of the 8 positions of play. Ultimately, body composition, rather than BMI, differentiated drafted from undrafted players. The capability of body fat percentage calculated using ADP testing to detect subtle differences in body composition, unlike BMI, further supports its usefulness in this particular population. Furthermore, reducing the body fat can be beneficial for prospective NFL players.

Our analysis was limited to prospective NFL football players. Therefore, changes in body composition in the cohort after their entrance into the NFL were not evaluated. However, our findings of BMI are consistent with previous studies involving NFL players (6). Therefore, we believe that our results provide credible evidence that obesity has been overestimated in NFL players.

Practical Applications

The obesity rate in prospective NFL players is overestimated when it is based on BMI and therefore, body fat percentage constitutes a more valid measure. Drafted players demonstrated a significantly lower body fat percentage in 6 of 8 positions. This is important to recognize for a strength and conditioning professional to be able to see the trends in true body mass and not only assess BMI. Performance and hence, draft status can be affected by body fat percentage; therefore, strength and conditioning professionals should consider using body fat percentage as a goal and not BMI when working with football players.

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