ABDOMINAL BODY COMPOSITION DIFFERENCES IN NFL FOOTBALL PLAYERS

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ABSTRACT

Bosch, TA, Burruss, TP, Weir, NL, Fielding, KA, Engel, BE, Weston, TD, and Dengel, DR. Abdominal body composition differences in NFL football players. J Strength Cond Res 28(12): 3313–3319, 2014—The purpose of this study was to examine visceral fat mass as well as other measures abdominal body composition in National Football League (NFL) players before the start of the season. Three hundred and seventy NFL football players were measured before the start of the season using dual-energy x-ray absorptiometry. Regional fat and lean mass was measured for each player. Players were categorized into 3 groups based on positions that mirror each other: linemen; linebackers/high ends/rushing backs and wide receivers/defensive backs. Significant differences were observed between the position groups for both lean and fat regional measurements. However, the magnitude of difference was much greater for fat measures than lean measures. Additionally, a threshold was observed (~114 kg) at which there is a greater increase in fat accumulation than lean mass accumulation. The increase in fat accumulation is distributed to the abdominal region where thresholds were observed for subcutaneous abdominal fat accumulation (12.1% body fat) and visceral abdominal fat accumulation (20.1% body fat), which likely explains the regional fat differences between groups. The results of this study suggest that as players get larger, there is more total fat than total lean mass accumulation and more fat is distributed to the abdominal region. This is of importance as increased fat mass may be detrimental to performance at certain positions. The thresholds observed for increased abdominal fat accumulation should be monitored closely given recent research observed that abdominal obesity predicts lower extremity injury risk and visceral adipose tissue’s established association with cardiometabolic risk.

KEY WORDS obesity, DXA, athletes, visceral fat

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INTRODUCTION

Body size is always a discussion topic in professional football players, players rise or fall in the draft based on size characteristics, or players reporting to camp overweight. Additionally, there is constant discussion about adding mass to a player’s frame. Rarely though are these changes quantified in terms of the type of mass (fat or muscle) being gained or lost and where the changes (region) are occurring. Previously, we have reported on positional differences in total body composition in National Football League (NFL) players (2). Although the majority of NFL players would be considered overweight or obese based on body mass index (BMI), their percent body fat is much closer to a normal or lean range. We and others observed the similarity in body composition of positions that mirror each other (i.e., offensive lineman vs. defensive linemen; wide receivers vs. defensive backs) (2,5–7,13,18). To date, studies in this population have focused on total body composition measurements. To the best of our knowledge, this is the first study to measure the abdominal and other regional body composition, including visceral adipose tissue (VAT), in NFL players. Recent advancements now allow dual-energy x-ray absorptiometry (DXA) to measure android and gynoid regions. Furthermore, DXA can differentiate between subcutaneous abdominal adipose tissue (SAAT) and VAT accumulation within the abdominal region. Visceral adipose tissue is an established marker for cardiometabolic risk (3,4,9,11,17,21), independent of subcutaneous abdominal fat and total body fat. More recently, abdominal obesity has been associated with increased risk of lower-body musculoskeletal injuries. These measurements could provide valuable insight into what type of tissue is being accumulated to account for positional differences that have been previously established for the entire body. Current methods of change in mass such as weight, BMI, and bioelectrical impedance are limited in their ability to distinguish between lean and fat mass or measure regional composition. Being able to reliably quantify regional composition changes would be of great value to coaches and trainers trying to get players to gain or lose weight. The purpose of this study was to examine abdominal body composition, including visceral mass in NFL position groups before the season. We hypothesized that regional lean
TABLE 1. Descriptive and total body composition measurements mean (± SD) for the sample.*

<table>
<thead>
<tr>
<th></th>
<th>Linemen (n = 123)</th>
<th>LB/TE/RB (n = 122)</th>
<th>WR/DB (n = 125)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age (y)</td>
<td>24.0± (2.4)</td>
<td>23.8± (2.2)</td>
<td>23.6± (2.0)</td>
</tr>
<tr>
<td>Height (cm)</td>
<td>191.9± (3.7)</td>
<td>186.7± (5.7)</td>
<td>183.8± (3.9)</td>
</tr>
<tr>
<td>Weight (kg)</td>
<td>137.1± (11.7)</td>
<td>109.6± (6.6)</td>
<td>92.3± (6.2)</td>
</tr>
<tr>
<td>BMI (kg·m⁻²)</td>
<td>37.3± (3.5)</td>
<td>31.5± (1.9)</td>
<td>27.3± (1.8)</td>
</tr>
<tr>
<td>Years played (y)</td>
<td>2.4± (2.3)</td>
<td>2.2± (1.9)</td>
<td>2.1± (2.0)</td>
</tr>
<tr>
<td>Percent fat (%)</td>
<td>27± (6)</td>
<td>17± (4)</td>
<td>12± (3)</td>
</tr>
<tr>
<td>Total fat (kg)</td>
<td>36.4± (10.0)</td>
<td>17.6± (4.5)</td>
<td>10.9± (3.4)</td>
</tr>
<tr>
<td>Total lean (kg)</td>
<td>95.9± (5.0)</td>
<td>87.3± (4.7)</td>
<td>77.1± (4.4)</td>
</tr>
</tbody>
</table>

*BMI = body mass index. If the variables share a letter within each row, they are not significantly different than one another at α = 0.05. Linemen = offensive and defensive linemen positions; LB/TE/RB = linebackers, tight ends, and running backs; WR/DB = wide receivers, defensive backs (includes safety and cornerbacks).

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and fat mass measurements would be significantly different between position groups.

**METHODS**

Experimental Approach to the Problem

Players were instructed to be at hemostasis before all testing sessions. When possible, scans were done in the morning on off days during physical examinations or before practice. A full body scan was acquired using a GE Healthcare Lunar iDXA (GE Healthcare Lunar, Madison, WI, USA). The iDXA is capable of scanning participants who weight up to 450 lbs, which makes it ideal for this population as none of them were in excess of this cutoff. Scans were analyzed using encore software version 13.6, revision 2. No hardware or software changes were made during the duration of the study. Two regions of interest were determined after the scan used for analysis was obtained from each participant from the Green Bay Packers professional football team. The University of Minnesota Institutional Review Board approved this study.

Participants were scanned using standard imaging and positioning protocols. Height and weight were measured by a standard wall stadiometer and medical beam scale, respectively.

Subjects

We assessed NFL players from the Green Bay Packers professional football team from 2006 to 2011 (ages: 20–40 years). Players were either active on the roster, free-agents, or prospective draft choices. One thousand three hundred and twenty-eight scans were performed during this time period. Three hundred and seventy NFL players (age: 20–35 years) had 1 measurement between April and August. If players had more than 1 scan, the scan used for analysis was randomly chosen using a pre-designated randomization scheme. Informed consent was obtained from each participant from the Green Bay Packers professional football team. The University of Minnesota Institutional Review Board approved this study. Participants were categorized by position into 1 of 7 categories: defensive backs (DB), defensive linemen (DL), linebackers (LB), offensive lineman (OL), running backs (RB), tight
ends (TE), and wide receivers (WR). They were then placed into groups of positions that mirror each other: linemen, LB/TE/RB, and WR/DB. This was done to increase the power for testing comparisons between groups. These groups were determined based on our previous work that observed similar body composition between positions that mirror each other.

Statistical Analyses
Descriptive statistics were calculated using mean ± SD by position group. An analysis of variance (ANOVA) was used to test if positional group mean values were equal to each other. Tukey's HSD (honest significant difference) method was used to compare each positional group mean against the next to correct for type I error from performing multiple comparisons ($p = 0.01$). Analysis of variance and Tukey’s HSD were also used to measure positional difference for regional measurements. We used segmented linear regression to determine whether fat mass and lean mass accumulation changes with increasing body weight. To determine when abdominal fat accumulation begins in relation to percent body fat, segmented linear regression was used to determine breakpoints in the association between VAT, subcutaneous abdominal fat, and percent body fat. The slopes above and below the identified breakpoints were analyzed by ANOVA to determine whether they were significantly different ($p = 0.05$). Boxplots were used to present the median (black line), range of total fat mass, total lean mass, SAAT, and VAT by position group. The boxplot displays the middle 50% of the data (box), range of the data (dashed lines), and possible outliers (open circles). All analysis was completed using R (R Foundation for Statistical Computing, Vienna, Austria).

RESULTS
Table 1 presents the characteristics and total body composition measurements for each position group for the cross-sectional
sample. Each position group had spent similar time in the NFL at the time of the scan. According to standard BMI classifications, the linemen position group would be classified as severely obese (BMI > 35 kg·m$^2$), the LB/TE/RB position group would be classified as moderately obese (BMI, 30–34.9 kg·m$^2$), and the WR/DB position group would be classified as overweight (BMI, 25–29.9 kg·m$^2$). Not 1 group had a mean BMI that was considered to be normal. Unlike the BMI classifications, only the linemen are classified as obese (>24%) using standard percent body fat classifications (8). The other 2 position groups would be classified as acceptable (15–20%) or healthy (11–14%) (8).

Table 2 presents the trunk body composition measurements for each position group. The linemen position group has significantly more fat and lean mass ($p < 0.05$) across all trunk composition variables compared with the other position groups. Compared with the WR/DB group, the LB/TE/RB group has significantly more fat and lean mass for all variables except VAT.

Table 3 presents the trunk body composition measurements for each position. Offensive lineman and DL are similar on all lean measurements but differed on many fat measurements. LB, TE, and RB were similar on all measurements except for trunk lean mass and android lean mass. For those 2 measurements, TE were similar to OL and DL. Wide receivers and DB were similar on all measurements and significantly different than all other positions. Offensive lineman had significantly more visceral fat than DL. There was no difference in visceral fat between LB, TE, RB, WR, or DB.

Figure 1A presents the relationship of lean mass and weight. A significant breakpoint in the slope was identified at 114.8 kg (95% CI = 111.4–118.2). The estimated slope before the breakpoint is 613.2 g (95% CI = 565.5–661.0). The estimated slope after the breakpoint is 215.1 g (95% CI = 170.0–260.3). Figure 1B presents the relationship of
fat mass and weight. A significant breakpoint in the slope was identified at 113.9 kg (95% CI = 110.3–117.4). The estimated slope before the breakpoint was 364.5 g (95% CI = 313–416.1). The estimated slope after the breakpoint was 759.8 g (95% CI = 715–804.6) (Figure 1A,B).

Figure 2A–D presents a boxplot of total fat mass, total lean mass, SAAT, and VAT by position groups. Linemen had a significantly higher range of fat mass, whereas there was much more overlap between position groups for lean mass. Linemen have a much greater range of SAAT compared with other positions. Similarly, linemen have a much greater range of VAT values compared with other position groups.

Figure 3 presents the relationship between SAAT and total percent fat mass. A significant breakpoint was identified at 12.1% (95% CI = 11.3–12.9). The estimated slope before this breakpoint was not significantly different than zero (−3.2 g, 95% CI = −61.5 to 55.03). The estimated slope after the breakpoint was 139.3 g (95% CI = 134.7–143.8). An ANOVA determined a significant difference between the slopes of subcutaneous accumulation before and after this breakpoint (p < 0.001). Figure 4 presents the relationship between VAT mass and total percent body fat. A significant breakpoint was identified at 20.1% body fat (95% CI = 18.9–21.3). The estimated slope before the breakpoint is not significantly different than zero (2.7 g [95% CI = 2.76 to 13.0]). The estimated slope after the breakpoint was 99.0 g (95% CI = 89.5–109.6). An ANOVA determined a significantly different slope in VAT accumulation before and after the ~20% threshold.

**DISCUSSION**

National Football League players are a unique population because their body composition is so different than the average population. Their BMI classifications are all extremely high, yet their percent fat classifications are relatively normal or lean in a majority of players. This suggests that the amount of lean mass all players have is much higher than the average population. This is evident in the lean mass differences between position groups. Although significantly different, the magnitude of difference between position groups for lean mass variables is, on average, between 10 and 15%. Conversely, the average fat mass difference between position groups is close to 200%, or a 2-fold difference. This was evident in Figure 1, lean mass accumulation decreases after ~114 kg (~250 lbs), whereas fat mass continues to increase. There is a shift in the type of tissue accumulated after that break point; before that point, increases in weight result in more lean mass than fat mass accumulation. However, after ~114 kg, more fat is accumulated than lean mass. This balance is of importance because body composition is associated with physical performance and injury risk, increasing the mass of a player needs to be closely monitored to ensure the increases are a result of lean tissue and not fat tissue, which could inhibit performance. Increases in body weight result in a proportional increase in the forces that articular, ligamentous, and muscular structures must resist (15). As such, joints would have a difficult time accommodating this increase in force with this disproportionate accumulation of fat mass to lean mass after ~114 kg.

Not surprisingly, as weight increased, abdominal fat accumulation also increased; however, the increase was more exponential than linear. This would suggest that as weight increases, more fat is being distributed to the abdominal region. When fat accumulates in the abdominal region, it can be stored in the visceral region or the subcutaneous region. In addition to increased injury risk (15,16), VAT is an independent risk factor for cardiovascular disease and insulin resistance (3,4,9,11,17,21).
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population, this accumulation occurred at different thresholds, suggesting that excess fat will be preferentially distributed to the SAAT region before VAT region. Subcutaneous abdominal adipose tissue accumulation begins around ~12% body fat and continues to increase as adiposity increases. Visceral adipose tissue accumulation does not begin until ~20% body fat, which supports that excess fat is preferentially stored subcutaneously. These thresholds would explain why regional fat mass was different, as we hypothesized, between the position groups for all measures except visceral fat.

Although there is no difference in VAT mass between LB/TE/RB and WR/DB groups, the linemen group had significantly higher VAT mass than the other 2 groups. These differences are a result of the differences in percent body fat between groups. The linemen had a higher average percent body fat than the other 2 groups. This average value was above 20% where VAT accumulation increases linearly with percent body fat. Linemen would be classified as obese based on percent body fat. In addition, there does not seem to be a direct relationship between subcutaneous abdominal fat mass and VAT mass until 20%. This suggests that the body will prevent distribution to VAT until all other depots have been filled. Recent evidence has linked an increase in abdominal adiposity with increased risk of lower extremity injuries (16), which is consistent with the association between increased BMI and injury rates in athletes (6,10,22). The mechanism behind this is yet to be identified, but these data would suggest that an increase in abdominal fat could play a role in the associated increased injury risk. The positional differences in VAT accumulation may have health consequences as well. Linemen have higher cardiovascular risk factors during their career (20) and increased prevalence of metabolic syndrome and cardiovascular disease after they retire (1,14).

Interestingly, compared with the WR/DB group, the LB/TE/RB group has 2 times as much android fat mass, yet their VAT mass is similar. These observations can be explained by the relationship of each regional depot with total percent mass. The LB/TE/RB and WR/DB groups were below this threshold, which likely resulted in minimal VAT accumulation. Additionally, the significantly lower percent body fat for the WR/DB group explains the difference in android fat mass with the LB/TE/RB group. To the best of our knowledge, this is the first study to observe distinct cut-points of linear accumulation for regional fat depots. This would be beneficial, especially for positions that rely on speed and quickness as increased abdominal fat accumulation could hinder performance.

Our previous study observed similarities in positions that mirror each other for measures of total body composition and bone mass and differences compared with positions that do not mirror. Our results demonstrate a similar pattern with respect to regional body composition. However, differences do exist between OL and DL for most fat measurements, which is consistent with the total fat difference we reported previously. In addition to that, this study observed that increases in weight above 114 kg results in more fat mass being accumulated than lean mass. This increase in fat mass is being accumulated in the abdominal region in both subcutaneous and visceral regions. This disproportionate increase in fat mass compared with lean mass could inhibit performance and put players at increased risk for injury.

**Practical Applications**

Dual-energy x-ray absorptiometry allows coaches, trainers, and players the unique opportunity to observe how increases in weight are being achieved. Is it an increase in lean or fat mass and more importantly, where is that mass being accumulated? The results of this study suggest that the differences in weight between position groups are a result of dramatic differences in fat mass, specifically abdominal fat mass. We have furthermore demonstrated a shift is tissue type accumulation (fat mass > lean mass) after 114 kg. Although it may be advantageous to for some positions to have more mass regardless of what type of tissue is being accumulated, most positions rely on speed and quickness, which could be inhibited by increased fat accumulation. Furthermore, accumulation of excess fat within the abdominal region could dramatically increase the risk of musculoskeletal injuries. Dual-energy x-ray absorptiometry can differentiate regional accumulation to monitor weight gain. More importantly, for players who are overweight, DXA would be able to reliably determine what type of tissue is being lost during weight loss as the goal would be to maintain lean mass while decreasing fat mass. The results of this study suggest that DXA provides a distinct advantage for monitoring weight change as it can distinguish the tissue type and region of accumulation or loss. Furthermore, the increased visceral accumulation in linemen observed in this study may explain the increased prevalence of cardiovascular disease (20) and metabolic syndrome in linemen compared with other positions after retirement (1,14).

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**References**


