Body Composition and Bone Mineral Density of National Football League Players

Donald R. Dengel,1,2 Tyler A. Bosch,1 T. Pepper Burruss,3 Kurt A. Fielding,1 Bryan E. Engel,2 Nate L. Weir,3 and Todd D. Weston4

1School of Kinesiology, University of Minnesota, Minneapolis, Minnesota; 2Department of Pediatrics, University of Minnesota Medical School, Minneapolis, Minnesota; 3Green Bay Packers Professional Football Team, Green Bay, Wisconsin; and 4GE Healthcare, Madison, Wisconsin

Abstract

Dengel, DR, Bosch, TA, Burruss, TP, Fielding, KA, Engel, BE, Weir, NL, and Weston, TD. Body composition and bone mineral density of national football league players. J Strength Cond Res 28(1): 1–6, 2014—The purpose of the present study was to examine the body composition of National Football League (NFL) players before the start of the regular season. Four hundred eleven NFL players were measured for height, weight and lean, fat, and bone mass using dual-energy x-ray absorptiometry (DXA). Subjects were categorized by their offensive or defensive position for comparison. On average, positions that mirror each other (i.e., offensive lineman [OL] vs. defensive lineman [DL]) have very similar body composition. Although OL had more fat mass than DL, they were similar in total and upper and lower lean mass. Linebackers (LB) and running backs (RB) were similar for all measures of fat and lean mass. Tight ends were unique in that they were similar to RB and LB on measures of fat mass; however, they had greater lean mass than both RB and LB and upper-body lean mass that was similar to OL. Quarterbacks and punters/kickers were similar in fat and lean masses. All positions had normal levels of bone mineral density. The DXA allowed us to measure differences in lean mass between arms and legs for symmetry assessments. Although most individuals had similar totals of lean mass in each leg and or arms, there were outliers who may be at risk for injury. The data presented demonstrated not only differences in total body composition, but also show regional body composition differences that may provide positional templates.

Key Words dual-energy x-ray absorptiometry, body composition, NFL, athletics, percentage fat

Introduction

There is a general perception that National Football League (NFL) players are bigger and carry more fat compared with NFL players from previous decades. Part of this statement may be true if we only use body mass index (BMI) to examine these players. Although players may have greater body mass, they may actually be leaner than players from previous decades.

The interest in the body composition of professional football players initially started over 40 years ago (14). Previous studies have reported that body composition is related to position (3,4,6,12,14). As advancements in methodology to examine body composition have developed, these newer methods have been applied to the study of NFL players. To date, most studies (6,14) have involved methods that use a 2-compartment model of body composition (i.e., fat mass and fat-free mass) and have only been able to focus on total body composition. The use of hydrostatic weighing through water or air displacement has long been considered to be the gold standard for determining body composition. However, the development of dual-energy x-ray absorptiometry (DXA), which is a 3-compartment model (i.e., fat mass, lean mass, and bone mass) is now considered the gold standard for measuring fat-free mass and bone mineral density (BMD).

Methods

Experimental Approach to the Problem

Players were instructed to be at hemostasis before all testing sessions. Whenever possible, studies were done in the...
morning on off days during physical examinations or before practice. Height and weight were measured by a standard wall stadiometer and medical beam scale, respectively. Body mass index was calculated as weight in kilograms divided by the square of height in meters. Total body imaging was acquired using a GE Healthcare Lunar iDXA (GE Healthcare Lunar, Madison, WI, USA) DXA and analyzed using enCore software version 13.6, revision 2. No hardware or software changes were made during the duration of the study. Participants were scanned using standard imaging and positioning protocols.

Subjects
We assessed NFL players from the Green Bay Packers professional football team from 2006 to 2011. Players were either active on the roster, free agents, or prospective draft choices. Four hundred eleven NFL players (age 20–38 yrs) were measured just before draft or before the start of the summer training camp. This informed consent of participants was obtained by the Green Bay Packers professional football team. Approval was granted by the University of Minnesota’s Institutional Review Board for statistical analysis of preexisting data that had been collected by the Green Bay Packers professional football team over a 6-year period.

Statistical Analyses
Participants were categorized by position into 1 of 9 categories defensive backs (DB), defensive lineman (DL), linebackers (LB), offensive lineman (OL), quarterbacks (QB), running backs (RB), tight ends (TE), and wide receivers (WR). Punters and place kickers were combined into 1 category named punters/kickers (PK). Descriptive statistics were calculated using mean \( \pm SD \) by position. An analysis of variance was used to test if positional mean was equal to each other. The TukeyHSD (honest significant different) method was used to compare each positional mean against the next to correct for type I error from performing multiple comparisons. Boxplots were used to present median (black line) and variation of 6 measurements by position (i.e., percent fat, total lean mass, lean mass ratio, difference in lean mass between legs and spinal BMD, and total mass-lean mass ratio). On each boxplots, the middle 50% of the data (box), range of the data (dashed lines), and possible outliers for each measure (open circles) were displayed. All analysis was completed using R (R Foundation for Statistical Computing, Vienna, Austria).

Results
Table 1 compares the physical characteristics (i.e., age, height, weight, and BMI) of the participants by position. If positions share a letter within each row, there is no significant difference \( (p > 0.05) \) between them. According to standard BMI categories, 2 positions OL and DL are classified as severely obese (BMI >35 kg·m\(^2\)). Three positions RB, LB, and TE are classified as moderately obese (BMI, 30–34.9 kg·m\(^2\)). The remaining positions, DB, QB, PK, and WR,
### Table 2. Mean (±SD) for body composition values of professional football players by position.

<table>
<thead>
<tr>
<th>Position</th>
<th>OL (n = 65)</th>
<th>DL (n = 58)</th>
<th>TE (n = 31)</th>
<th>LB (n = 55)</th>
<th>RB (n = 36)</th>
<th>PK (n = 19)</th>
<th>QB (n = 22)</th>
<th>DB (n = 69)</th>
<th>WR (n = 56)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fat (%)</td>
<td>28.8±(3.7)</td>
<td>25.2±(7.6)</td>
<td>16.9±(3.8)</td>
<td>17.0±(3.2)</td>
<td>16.0±(4.0)</td>
<td>19.2±(4.5)</td>
<td>19.6±(4.6)</td>
<td>12.1±(3.3)</td>
<td>12.5±(3.1)</td>
</tr>
<tr>
<td>Fat mass (kg)</td>
<td>39.3±(6.0)</td>
<td>33.3±(12.3)</td>
<td>18.4±(4.5)</td>
<td>17.9±(3.8)</td>
<td>16.3±(5.3)</td>
<td>18.2±(4.8)</td>
<td>19.5±(6.0)</td>
<td>10.6±(3.5)</td>
<td>11.3±(3.4)</td>
</tr>
<tr>
<td>Lean mass (kg)</td>
<td>96.5±(4.5)</td>
<td>95.2±(5.5)</td>
<td>90.7±(4.0)</td>
<td>87.3±(3.5)</td>
<td>84.5±(4.9)</td>
<td>76.1±(4.8)</td>
<td>78.9±(5.1)</td>
<td>76.1± (4.2)</td>
<td>78.3±(4.3)</td>
</tr>
<tr>
<td>Total BMC (kg)</td>
<td>5.1±(0.35)</td>
<td>5.0±(0.36)</td>
<td>4.9±(0.33)</td>
<td>4.6±(0.29)</td>
<td>4.5±(0.36)</td>
<td>4.1±(0.32)</td>
<td>4.4±(0.31)</td>
<td>4.2±(0.29)</td>
<td>4.3±(0.38)</td>
</tr>
<tr>
<td>Upper lean mass (kg)</td>
<td>57.3±(3.5)</td>
<td>55.8±(3.3)</td>
<td>54.5±(2.8)</td>
<td>51.9±(3.0)</td>
<td>50.0±(3.1)</td>
<td>46.2±(3.9)</td>
<td>47.8±(3.5)</td>
<td>45.4±(2.4)</td>
<td>46.4±(2.9)</td>
</tr>
<tr>
<td>Lower lean mass (kg)</td>
<td>35.1±(2.3)</td>
<td>35.2±(3.6)</td>
<td>32.2±(1.7)</td>
<td>31.5±(1.8)</td>
<td>30.6±(2.7)</td>
<td>26.2±(1.7)</td>
<td>27.3±(2.5)</td>
<td>27.0±(2.0)</td>
<td>28.2±(2.1)</td>
</tr>
<tr>
<td>U/L lean ratio</td>
<td>1.64±(0.17)</td>
<td>1.60±(0.19)</td>
<td>1.69±(0.09)</td>
<td>1.66±(0.14)</td>
<td>1.65±(0.15)</td>
<td>1.77±(0.16)</td>
<td>1.77±(0.17)</td>
<td>1.69±(0.10)</td>
<td>1.65±(0.13)</td>
</tr>
<tr>
<td>Total mass/lean mass ratio</td>
<td>1.41±(0.07)</td>
<td>1.35±(0.13)</td>
<td>1.20±(0.06)</td>
<td>1.21±(0.05)</td>
<td>1.19±(0.06)</td>
<td>1.14±(0.07)</td>
<td>1.25±(0.07)</td>
<td>1.14±(0.05)</td>
<td>1.14±(0.04)</td>
</tr>
<tr>
<td>Difference in leg lean mass (kg)</td>
<td>−0.25 to 0.40</td>
<td>0.18 to 0.33</td>
<td>0.29 to 0.40</td>
<td>0.32 to 0.35</td>
<td>0.14, 0.44</td>
<td>0.28 to 0.37</td>
<td>0.21 to 0.39</td>
<td>0.24 to 0.43</td>
<td></td>
</tr>
<tr>
<td>Spine BMD (g/cm²)</td>
<td>1.59±(0.13)</td>
<td>1.57±(0.13)</td>
<td>1.52±(0.12)</td>
<td>1.53±(0.13)</td>
<td>1.51±(0.11)</td>
<td>1.40±(0.13)</td>
<td>1.45±(0.13)</td>
<td>1.47±(0.11)</td>
<td>1.49±(0.12)</td>
</tr>
</tbody>
</table>

If positions share a letter within each row, they are not significantly different at p < 0.05.

OL = offensive lineman; DL = defensive lineman; TE = tight ends; LB = linebacker; RB running back; PK = punters/kickers; QB = quarterback; DB = defensive back; WR = wide receivers; BMC = bone mineral content; U/L Lean Ratio = the ratio of upper-body lean mass to lower-body lean mass; BMD = bone mineral density.

### Table 3. Range for body composition values of professional football players by position.

<table>
<thead>
<tr>
<th>Position</th>
<th>OL (n = 65)</th>
<th>DL (n = 58)</th>
<th>TE (n = 31)</th>
<th>LB (n = 55)</th>
<th>RB (n = 36)</th>
<th>PK (n = 19)</th>
<th>QB (n = 22)</th>
<th>DB (n = 69)</th>
<th>WR (n = 56)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Percent fat (%)</td>
<td>14.3–35.8</td>
<td>12.1–39.1</td>
<td>8.1–25.4</td>
<td>10.4–25.7</td>
<td>10.6–25.8</td>
<td>10.9–27.9</td>
<td>11.3–30.5</td>
<td>7.1–23.9</td>
<td>7.7–22.1</td>
</tr>
<tr>
<td>Fat mass (kg)</td>
<td>18.1–52.4</td>
<td>12.6–62.5</td>
<td>8.6–29.4</td>
<td>11.2–28.9</td>
<td>9.5–29.4</td>
<td>10.4–29.4</td>
<td>11.1–34.3</td>
<td>5.9–23.1</td>
<td>6.2–23.1</td>
</tr>
<tr>
<td>Lean mass (kg)</td>
<td>87.5–108.7</td>
<td>81.5–109.0</td>
<td>80.5–98.0</td>
<td>80.5–96.3</td>
<td>74.0–92.1</td>
<td>68.2–84.7</td>
<td>70.3–91.8</td>
<td>68.5–89.6</td>
<td>71.1–88.7</td>
</tr>
<tr>
<td>Total BMC (kg)</td>
<td>4.2–5.9</td>
<td>4.2–5.8</td>
<td>4.2–5.6</td>
<td>4.0–5.4</td>
<td>3.8–5.6</td>
<td>3.5–4.7</td>
<td>3.9–5.3</td>
<td>3.4–4.8</td>
<td>3.6–5.3</td>
</tr>
<tr>
<td>Upper lean mass (kg)</td>
<td>50.2–68.4</td>
<td>46.7–63.6</td>
<td>48.1–58.8</td>
<td>44.9–57.2</td>
<td>42.9–56.3</td>
<td>39.9–54.0</td>
<td>41.3–54.9</td>
<td>40.5–54.9</td>
<td>42.0–52.2</td>
</tr>
<tr>
<td>Lower lean mass (kg)</td>
<td>27.5–41.1</td>
<td>24.2–34.7</td>
<td>23.6–45.5</td>
<td>22.6–36.1</td>
<td>22.6–34.8</td>
<td>23.3–30.6</td>
<td>23.9–35.0</td>
<td>22.2–33.1</td>
<td>24.5–32.8</td>
</tr>
<tr>
<td>U/L lean ratio</td>
<td>1.38–2.32</td>
<td>1.26–2.44</td>
<td>1.55–1.96</td>
<td>1.33–1.98</td>
<td>1.46–2.08</td>
<td>1.54–2.26</td>
<td>1.51–2.30</td>
<td>1.53–1.93</td>
<td>1.42–1.88</td>
</tr>
<tr>
<td>Total mass/lean mass ratio</td>
<td>1.17–1.56</td>
<td>1.14–1.64</td>
<td>1.09–1.34</td>
<td>1.12–1.35</td>
<td>1.12–1.35</td>
<td>1.12–1.39</td>
<td>1.13–1.45</td>
<td>1.08–1.31</td>
<td>1.08–1.28</td>
</tr>
<tr>
<td>Difference in leg lean mass (kg)</td>
<td>−2.1 to 1.5</td>
<td>−3.7 to 1.6</td>
<td>−1.1 to 1.2</td>
<td>−0.94 to 0.85</td>
<td>−0.95 to 0.94</td>
<td>−0.45 to 1.7</td>
<td>−0.86 to 1.1</td>
<td>−1.1 to 1.4</td>
<td>−0.88 to 1.2</td>
</tr>
<tr>
<td>Spine BMD (g/cm²)</td>
<td>1.3–1.9</td>
<td>1.3–1.8</td>
<td>1.3–1.8</td>
<td>1.3–1.8</td>
<td>1.3–1.7</td>
<td>1.2–1.6</td>
<td>1.2–1.7</td>
<td>1.3–1.7</td>
<td>1.2–1.8</td>
</tr>
</tbody>
</table>

OL = offensive lineman; DL = defensive lineman; TE = tight ends; LB = linebacker; RB running back; PK = punters/kickers; QB = quarterback; DB = defensive back; WR = wide receivers; BMC = bone mineral content; U/L lean ratio = the ratio of upper-body lean mass to lower-body lean mass; BMD = bone mineral density.
are all classified as overweight (BMI, 25–29.9 kg·m²). We observed no significant differences in the number of years played in the NFL between positions, except QB. On average, they had spent significantly longer time in the NFL, before the scan, compared with other positions. Table 2 compares the body composition data of the participants by position. We observed that DB and WR were never significantly different than each other. The OL had significantly more fat mass than DL, but the 2 positions were similar for all measures of lean mass. Interestingly, we observed that LB and RB were not significantly different from each other for all measures. Tight ends were significantly different from OL on all measures except upper-body lean mass and the ratio of upper-body to lower-body lean mass. Table 3 presents the ranges of the body composition data by position. Figure 1 is a boxplot of the data for percent fat by position. Figure 2 presents the data for total lean mass by position. We observe that positions that typically mirror each other have very

![Figure 1](image1.png)

**Figure 1.** Boxplot of percent fat by position. DB = defensive back; DL = defensive lineman; LB = linebacker; OL = offensive lineman; PK = punters/kickers; QB = quarterback; RB = running back; TE = tight ends; WR = wide receivers.

![Figure 2](image2.png)

**Figure 2.** Boxplot of total lean mass by position. DB = defensive back; DL = defensive lineman; LB = linebacker; OL = offensive lineman; PK = punters/kickers; QB = quarterback; RB = running back; TE = tight ends; WR = wide receivers.

![Figure 3](image3.png)

**Figure 3.** Boxplot of ratio of U/L lean mass by position. DB = defensive back; DL = defensive lineman; LB = linebacker; OL = offensive lineman; PK = punters/kickers; QB = quarterback; RB = running back; TE = tight ends; WR = wide receivers.

![Figure 4](image4.png)

**Figure 4.** Boxplot of difference in right and left leg lean mass by position. DB = defensive back; DL = defensive lineman; LB = linebacker; OL = offensive lineman; PK = punters/kickers; QB = quarterback; RB = running back; TE = tight ends; WR = wide receivers.
similar lean mass. Offensive linemen are almost equal to DL. Running backs are similar to LB. Wide receivers are similar to DB. Tight ends were between DL and LB. Figure 3 presents the ratio of upper/lower lean mass (U/L ratio) by position. The lower the ratio, the greater amount of lower-body mass the athlete has. Defensive and offensive linemen have the lowest U/L ratio and the highest lower-body lean mass, whereas QB and PK had the highest U/L ratios and lowest lower-body lean mass. Tight ends, RB, and LB had similar U/L ratios and lower-body lean mass. Figure 4 presents the differences in lean mass between each leg. This is the difference between the left side minus the right side. The first and third quartiles are presented in Table 2 and are also shown by the upper and lower edge of each box within each positional boxplot. Players located outside the first and third quartiles should work to balance leg lean mass. Figure 5 presents the data for spine BMD. Offensive lineman had the highest density; however, this difference was not significantly different than DL, LB, RB, or TE. Players with a density below the first quartile (bottom of box) may be at increased risk of fracture risk. Figure 6 presents the ratio of total body mass to lean body mass by position. We observed that DB, WR, LB, and RB had the lowest ratios, whereas DL and OL had the highest ratios.

**DISCUSSION**

Although there have been a few papers (3,4,12,14) that have been written on the body composition of professional football players, this study is unique that by using DXA, we are not only able to characterize fat and lean tissue mass, but also bone mass. In addition, the use of DXA allows us to also examine regional body composition and total body composition.

A number of studies (5,7,9,13) have suggested a high prevalence of obesity in professional football players. Most of these studies have used BMI to categorize player’s level of body composition. Unfortunately, BMI does not distinguish between fat and lean tissue. In these highly trained athletes, this typically results in the overstatement of disease risk. In studies (6,14) that have used more advance methods to measure body composition so that lean and fat tissue can be determined, most professional football players are considered to have healthy body composition when using percent fat mass. This study supports these other studies in that although the average BMI for most positions shows the athlete to be overweight or obese, when the percent fat is used, these athletes are actually lean. The only exception to this are the OL and DL, who even when using percent fat would considered overweight or obese in some cases.

Kraemer et al. (6) suggested that offensive and defensive positions that mirror each other, such as OL and DL or DB and WR would have similar body compositions values. In this study, we also observed similar overall patterns of body compositions in individuals who played offensive or defensive that mirrored each other. Although OL had a higher overall percent fat and total fat mass than DL, the 2 positions were similar in overall bone and lean mass. They also had similar amounts of upper and lower lean mass. Therefore, their U/L ratio was also similar for OL and DL. These positions are meant to be anchors; neither player wants to give up position, so a lower U/L ratio would provide a better anchor than a player, that is, top heavy (high U/L ratio).

Tight ends proved to be a unique position having an overall percent fat similar to RB and LB, but having an
Overall lean body mass greater than both RB and LB. Regionally, the TE had more upper-body lean mass than both RB and LB, but the lower-body lean mass was similar for the 3 positions. Tight ends had as much upper-body lean mass as both OL and DL. This may be because of the demands of the position in having to block DL players, but having to run routes against LB and DB. This may also be a result of TE being used more as a receiver than a blocker. There is more emphasis placed on speed and elusiveness than being an anchor position.

As expected, DB and WR had similar overall percent body fats and similar total lean body mass. Their distribution of lean body for DB and WR was also very similar with the same distribution of lean body mass in the upper and lower regions. Speed is a priority for these positions, so it is not surprising that there total mass to lean mass ratios were significantly lower than all other positions.

To our knowledge, this is the first article to present body composition data as determined using DXA on professional football players. Our data create templates for body dimensions of NFL players at different positions. The use of the DXA provides new data on body composition such as bone mass and regional assessments of fat, lean, and bone mass.

**PRACTICAL APPLICATIONS**

The DXA allows coaches and athletic trainers the opportunity to examine differences in muscle symmetry as a possible precursor to injury. For example, legs can be examined as left vs. right leg. Large differences in lean mass between legs could increase the risk of noncontact injury. Several studies (1,2,11) have shown that strength imbalances have an association to increased risk of noncontact injuries, although Shambaugh et al. (10) observed leg girth differences are associated with increased risk of noncontact injuries. There are limitations of these studies. The leg girth measurements cannot differentiate between fat and muscle, whereas the strength imbalances are measured using non–weight-bearing procedures (isokinetic torque). Dual-energy x-ray absorptiometry is able to differentiate leg mass into bone, muscle, and fat to determine muscular imbalances. Players measured in the whiskers (dashed lines) of Figure 4 should address this difference. The DXA could also be used in rehabilitation to examine differences in lean mass between arms or legs before and after rehabilitation. Issues regarding bone density can also be examined, for instance, Figure 5 presents the data for spine BMD. Low BMD in the spine could indicate an increased risk for spinal injury in a collision sport. Players identified with values below the first quartile (bottom line of box) should address this low value with supplementation and exercises to strengthen the muscles that support the spine.

**REFERENCES**