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Body Composition and Bone Mineral Density of Division 1 Collegiate Football Players, a Consortium of College Athlete Research (C-CAR) Study

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Abstract

The purpose of the present study was to generate normative data for total and regional body composition in Division 1 collegiate football players using dual-energy X-ray absorptiometry (DXA) and examine positional differences in total and regional measurements. Data was used from the Consortium of College Athlete Research (C-CAR) group. Four hundred-sixty-seven players were included in this study. Height, weight, total and regional fat mass, lean mass and bone mineral density were measured in each athlete in the preseason (June–August). Players were categorized by their offensive or defensive position for comparisons. Linemen tended to have the higher fat and lean mass measures ($p<0.05$ for all) compared to other positions. Positions that mirror each other (ex. Linemen) had similar body composition and body ratios. All positions were classified as overweight or obese based on BMI (>25 kg/m^2), yet other than offensive and defensive linemen, all positions had healthy percent body fat (13–20%) and low visceral fat mass (<500 g). The data presented here provide normative positional data for total and regional fat mass, lean mass, and bone density in Division 1 collegiate football players. Player position had a significant effect on body composition measures and is likely associated with on-field positional requirements. From a player health perspective, even though all positions had relatively high BMI values, the majority of positions had relatively low body fat and visceral fat, which is important for the health of players during and after their playing career. The increased accuracy and reliability of DXA provides greater information regarding positional differences in college football players compared to other methods.

Keywords

dual x-ray absorptiometry; athletes; visceral fat

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INTRODUCTION

American football provides a unique population within which to measure body mass and distribution of mass (3, 4, 9, 12, 14, 15, 22–24, 26, 29, 32). Each position has physical demands that require different body types to be successful (10, 11, 16–19). Generally speaking, individuals are trying to maximize their total mass-lean mass ratio (i.e. percent body fat[%BF]), but the optimal total mass for each position is highly variable (9, 12). Managing body composition to meet the demands of their position and sport presents a unique challenge for sports performance staff. To date, there is limited normative data for total and regional body composition values by position in a large sample of collegiate football players using dual x-ray absorptiometry (DXA). Identifying the positional averages for total and regional body composition, using a gold-standard methodology, would help guide expectations for body composition in football players. The purpose of this study was to provide accurate and reliable measurements of total and regional body composition for Division 1 football players.

A variety of methods have been used to quantify body composition in previous studies of football players, both professional and collegiate (3, 4, 9, 12, 14, 15, 22–24, 26, 29, 32). While many have relied on anthropometrics, more recent reports have measured body composition using DXA. DXA is a three compartment method that quantifies fat mass, lean mass and bone mass (and density), and is considered the "*gold standard*" for measuring body composition. Moreover, recent advancements in DXA software allow for regional segmentation of body composition, comparison of right and left sides of the body, as well as the estimation of visceral fat mass (VAT). This additional information allows for a more detailed evaluation of the distribution of mass and the estimate of VAT has important implications for health and well-being of players (1, 5, 9, 14–15, 25, 27). Researchers and sports performance trainers can use this information to determine mass distribution ratios that may have a stronger relationship with speed, strength and power than traditional total measures of body composition (i.e. %BF, total lean mass, total fat mass). Previously, using DXA, we reported positional characteristics of total and regional body composition in professional football players (12, 23). Significant findings from those studies include that positions that mirror each other have similar body composition characteristics and on average fat mass accumulates at a greater proportion per pound increase in weight in players above 250 pounds (9).

The purpose of this study was to use DXA derived total and regional body composition measures to define position-specific characteristics in a large cohort of NCAA Division 1 football athletes from the Consortium of College Athlete Research (C-CAR). This information can be used to identify normative data using DXA for each football position. Practically, this information provides coaches, performance staff and players clear expectation of their body composition and bone density for their positions. Moreover, this data would provide distinction between the type and distribution of mass for each athlete. We hypothesized that positions that mirror each other would have similar body composition characteristics.

METHODS

Experimental Approach to the Problem

Data for this study was obtained from the C-CAR research group consisting of researchers from Texas Christian University (TCU), University of Texas at Austin (UT), University of Kansas (KU) and University of Minnesota (UMN). By combining data collected from several universities we can increase our sample size to provide accurate and reliable positional data for total and regional body composition. This study used a retrospective analysis from previously collected data in order to test whether total and regional body composition data differs between Division 1 football positions. All players were scanned on GE Healthcare Lunar systems (iDXA/Prodigy GE Healthcare Lunar, Madison, WI, USA). To improve accuracy and reliability of the data raw DXA scan files were collected from each university and analyzed at the University of Minnesota using enCore software version 16.2. The same trained individual reviewed each scan for the correct placement of the ROI boxes to measure regional body composition. VAT mass was estimated using CoreScan (GE Healthcare) as described previously (8, 9, 13).

Subjects

A total of 467 individuals (UT n = 172, KU n= 142, TCU n = 45, UMN n= 108) were scanned from the 4 schools from 2011–2016, and the number of scans for each individual ranged from 1–16 for a total of 1794 scans. The age of the population ranged from 17–24 years. This study was approved by the University of Minnesota Institutional Review Board, the data transfer from other universities was approved by each individual university. Subjects were informed of the benefits and risks of the investigation prior to signing an institutionally approved informed consent document to participate in the study. For individuals under the age of 18 years of age, parental or guardian consent was also obtained. For this study individuals with more than 1 scan were randomly sampled and the randomization was stratified to provide similar range of ages for each position. For this study only scans conducted during the pre-season were included (June 1st – August 1st). Participants were in their general preparation phase (June) or specific phase (July) or their training cycle. Prior to the scan, each participant had height and weight measured by a standard stadiometer and electronic scale, respectively. All players scanned were instructed to maintain their hydration status prior to scans. As much as possible scans were done on off days or at least 2 hours after a practice session. Participants were scanned using standard imaging and positioning protocols. Participants were grouped into positions as follows: defensive backs (DB), wide receivers (WR), tight ends (TE), linebackers (LB), running backs (RB), offensive linemen (OL), defensive linemen (DL), quarterbacks (QB) and special teams (ST). For the purpose of this study participants were not grouped as underclassmen or upperclassmen. This is because only age was recorded for subjects. The accuracy of classifying class level based on age would have been limited without further information.

Statistical Analyses

Descriptive statistics were calculated using mean + SD by position. An analysis of variance was used to test if positional means were equal to each other. The TukeyHSD (honest significant difference) method was used to compare each mean and correct for type I error from multiple comparisons with an adjusted significance level of $p<0.05$. In addition to standard total and regional metrics, an upper total mass to legs total mass ratio (ULR), total upper mass to lean leg mass ratio (TULLR), lean upper mass to lean leg mass ratio (LULLR) and gynoid (glute) lean mass to leg lean mass ratio (GLR) were calculated for each position. For all of these ratios, upper body equals trunk and arms and total includes fat, lean and bone mass. These ratios were used to compare the type and distribution of mass were different between positions. All analyses were 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 cohort by position. Positions that share a letter within each row were not significantly different than one another. Age was similar across positions. LB and DL would be classified as Class I obese (30.0–34.9 kg/m^2), OL as Class II obese (35.0–39.9 kg/m^2) and all other positions as overweight (25.0–29.9 kg/m^2) based on standard BMI categories. The range for each of these variables in presented in Table 2. However, as shown in Table 3, only OL would be classified as obese and DL as overweight based on %BF.

Table 3 presents the total and regional body composition averages by position. OL had much higher %BF than all other positions. With the exception of OL and DL, there were no significant differences on any measures between offensive and defensive positions that mirror each other, but these values were different than other position groups. For all fat measures and fat ratios, DL was significantly lower than OL, but there were no differences between DL and OL for any lean measures and lean ratios. OL had significantly higher VAT mass ($p<0.05$) compared to all positions, except DL and RB. Table 4 presents the ranges of total and regional body composition variables by position. In general, each position had a wide range of values for each total and regional body composition variable.

Table 5 presents the mean total, total less head, leg and spine bone mineral densities by position as well as the average z-score for total bone density (based on the enCore normative database). Consistent with body composition variables, total and regional bone mineral densities were similar among positions that mirror each other; however, there were fewer positional differences. DL had the highest average density and ST athletes had the lowest average for each measurement.

DISCUSSION

While other studies have reported body composition in collegiate football players, this study provides the largest cohort of collegiate football players with total and regional body composition measured by DXA, the "*gold standard*"in body composition. This study builds on previous studies by reporting positional bone mineral density and VAT mass differences in collegiate football players. These data provide new normative data for positional body composition characteristics of collegiate football players that can be used to guide nutrition and training plans as well as monitor player health and wellness.

Consistent with previous work (5, 13,14, 24, 26), most collegiate Division 1 football positions are classified as overweight or obese based on BMI. This is distinctly different than our previous report in NFL players where the majority of positions were classified as Class I and II obese (12). Also consistent with other reports (9, 12), positions, except OL and DL, are classified as healthy or athletic for %BF (13–20%). The %BF values reported here are slightly higher than other reports (22, 24) using other methods (exs. Underwater weighing, bioelectrical impedance); however, they are consistent with previous studies on NFL players (12) and the recent report by Trexler et al. (30) that used DXA. Additionally, this report builds on previous work by combining data from four different universities in different regions of the United States increasing the diversity of the cohort. The values reported in this study can be used as normative body composition data for NCAA Division I football players.

With the exception of OL and DL, positions that mirror each other (DB vs WR, LB vs RB and LB vs TE) had no significant differences for any total or regional body composition measure or ratio. For OL vs DL, there were no differences for any total or regional lean measures, but OL had higher total and regional fat measures. In general, when comparing mirrored positions against other mirrored positions, there was an increase in all total and regional body composition measures from DB & WR to LB & RB to DL & OL. While there were no significant differences between LB & RB or LB & TE on any measure, there were differences between RB and TE. A closer look at the data indicates that, although many of the differences are not significant, RB<LB<TE for every total and regional body composition measure. The similarities between positions that mirror each other was also observed in different body mass ratios. While speculative, the mirroring of position for total and regional measures, as well as ratios of mass distribution, may indicate a relationship with for on-field requirements because the mass distribution and ratio of distribution would influence how athletes move their body through space. Generally speaking, an OL can be successful with a higher fat mass (and total mass), because they are not required to cover much ground, whereas their counterpart, DL, are required to get up field quickly and in some systems drop back into pass coverage. Further evidence of this is observed in TE/LB/RB groups and DB/WR groups. These positions require speed and quickness, and the ability to cover larger areas. In each case the total and regional differences between offensive and defensive players were not significantly different. More research is needed to establish how regional distribution of mass effects, speed, force and on-field performance. However, the ability to accurately and reliably measure these ratios provides an opportunity for longitudinal studies, designed to answer these questions, to draw stronger conclusions.

Most positions had a wide range for each total and regional body composition variable. This may be a result of grouping similar positions together (ex. safety and cornerback as DB) and not delineating between players who played a significant amount and those who didn't. To maintain a relatively large sample size for each position we grouped all positions together (ex. guard, center, tackle as OL). The total and regional body composition may differ slightly between these specific positions that results in a larger range. Future studies comparing exact positions (ex. DT, MLB) would help define specific position normative data. Grouped studies such as this one examining specific positions would need to control for the scheme of the team because defensive tackles may look very different in a 3–4 scheme versus a 4-3 scheme.

Finally, from a health perspective, there were fewer positional differences for total and regional bone density and VAT measurements (compared to fat and lean mass). Normative data on bone density is important for athletic populations. This cohort had higher bone density compared to non-athletic populations (the average total BMD for each position group was 2.1 – 3.4 SD above normal, measured by z-score); however, when compared within similar body types, it's possible to identify individuals who may have potential deficiencies in bone density. Individuals within a position, that are near the lower limits for total or regional bone density (ex. 10th percentile) may be at greater risk of bone injury in a collision sport. Similarly, VAT mass has been implicated and associated with significant metabolic dysfunction in children and adult populations (6–8). We have previously identified a proportional shift of accumulation of VAT, even in an athletic population, with increasing adiposity and total mass (9). Monitoring VAT both during and after a playing career, in addition to other body composition measures, will be important for athletes to maintain health and healthy metabolic function (5, 13,15, 25, 27). This study, which shows the mean VAT values for OL and DL to be 2 – 4 times greater than for the other positions, is consistent with our NFL population (9) and others that have shown linemen are at the greatest risk of cardiovascular and metabolic dysfunction after retirement (1, 2,18, 25, 31).

In conclusion, this study has several strengths: it includes a large cohort (n=467); gold standard body composition (DXA); and standardized analyses (every scan was analyzed using the same software and reviewed by the same technician). This study does have a few limitations. First, while several precautions were taken to control for differences between sites (each site used standard best practices), there is the potential for bias based on scan location. Additionally, scanning a team in a feasible amount of time limits the control of time of day for scanning, nutrition, hydration etc. Best practices were used by each University and when possible similar position groups were scanned at the same times of day. The large sample size should limit the influence of these biases. Moreover, this report is a cross-sectional assessment of body composition and does not address the change over time in collegiate athletes.

PRACTICAL APPLICATIONS

The use of DXA to measure body composition in athletic populations has increased in recent years. DXA is one of the most accurate methods to assess both total and regional body composition. The data from this study provides accurate and reliable body composition and bone mineral density data for Division 1 football positions. This data can be used by athletes and coaches as reference data when using DXA to measure total and regional body composition as these numbers will likely differ from other body composition methods. Moreover, this data provides information regarding the type and distribution of mass for each position. More research is needed to understand how distribution of mass effects strength, force and speed characteristics, but the similarity between mirrored positions observed in this study and our previous report in NFL athletes suggests it plays a role in on field requirements. The data presented in this report can be used to identify ideal ranges for each position in collegiate football players. However, it is important to clarify that the data presented here is averages and ranges for each position. In practice, performance metrics must be taken into account, since each individual will have their own optimal body type to maximize performance.

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Table 1

Positional Characteristics (mean±SD)

	OL (n=83)	DL (n=53)	TE (n=30)	LB (n=58)	RB (n=36)	DB (n=78)	WR (n=75)	QB (n=23)	ST (n=31)
Age (yrs)	19.6[a] (1.5)	19.6[a] (1.4)	19.7[a] (1.5)	19.6[a] (1.5)	19.7[a] (1.5)	19.5[a] (1.5)	19.4[a] (1.4)	19.2[a] (1.4)	19.7[a] (1.4)
Weight (kg)	135.5[a] (11.8)	120.4[b] (14.2)	107.4[c] (9.6)	102.0[c] (6.6)	95.1[d] (9.6)	87.8[e] (6.5)	87.2[e] (8.8)	93.9[de] (8.2)	92.0[de] (9.2)
Height (cm)	192.9[a] (4.9)	189.1[b] (3.7)	190.5[ab] (5.5)	184.2[c] (3.1)	179.4[d] (3.9)	181.1[d] (4.1)	183.9[c] (6.5)	186.9[bc] (4.9)	184.8[c] (6.4)
BMI (kg/m^2)	36.4[a] (3.1)	33.7[b] (4.5)	29.5[c] (2.1)	30.0[c] (2.0)	29.4[c] (2.2)	26.5[d] (2.0)	25.7[d] (1.7)	26.8[d] (1.9)	26.9[d] (2.1)

For each row, if a position does not share a letter it is significantly different at an adjusted ($p<0.05$)

OL= offensive Line, DL = defensive line, TE = tight end, LB = linebacker, RB= running back, DB = defensive back, WR = wide receiver, QB = Quarterback, ST= special teams

Table 2

Range of Characteristics by Position

	OL (n=81)	**DL (n=53)**	**TE (n=30)**	**LB (n=58)**	**RB (n=37)**	**DB (n=79)**	**WR (n=75)**	**QB (n=23)**	**ST (n=31)**
Age (yrs)	17–24	17–22	18–23	17–22	18–23	18–23	17–23	18–22	17–23
Weight (kg)	97–172	96–147	83–128	86–119	76–111	73–99.7	65–109	80–111	76–116
Height (cm)	180–206	178–197	180–208	177–191	170–188	173–194	169–197	175–194	165–197
BMI (kg/m^2)	28.7–47.2	25.8–42.2	25.5–35.7	24.6–33.4	24.8–31.9	22.1–30.1	21.7–31.6	23.7–30.5	22.5–31.9

OL= offensive Line, DL = defensive line, TE = tight end, LB = linebacker, RB= running back, DB = defensive back, WR = wide receiver, QB = Quarterback, ST= special teams

Table 3

Positional Body Composition Characteristics mean (±SD)

	OL (n=83)	**DL (n=53)**	**TE (n=30)**	**LB (n=58)**	**RB (n=36)**	**DB (n=78)**	**WR (n=75)**	**QB (n=23)**	**ST (n=31)**
Percent Fat (%)	30.8^{a} (4.2)	23.5^{b} (7.0)	19.8^{c} (3.9)	18.8^{c} (4.9)	15.3^{de} (3.9)	13.3^{e} (3.2)	14.1^{de} (3.6)	17.2^{cd} (4.2)	19.9^{c} (5.5)
Total Lean Mass (kg)	89.5^{a} (6.5)	87.6^{a} (6.8)	82.2^{b} (6.5)	79.5^{bc} (5.2)	77.3^{cd} (6.8)	72.4^{e} (5.2)	71.6^{e} (6.5)	74.4^{de} (6.3)	70.4^{e} (6.0)
Total Fat Mass (kg)	40.1^{a} (7.9)	27.8^{b} (10.8)	20.5^{c} (5.3)	18.5^{c} (5.4)	14.1^{de} (4.6)	11.2^{e} (3.0)	11.9^{e} (3.7)	15.5^{cde} (4.4)	17.7^{cd} (5.8)
Trunk Lean Mass (kg)	39.5^{a} (3.2)	38.3^{a} (3.0)	37.7^{ab} (3.3)	35.8^{bc} (2.7)	34.5^{cd} (3.3)	32.7^{e} (2.5)	32.7^{de} (3.0)	34.4^{cde} (2.8)	32.9^{de} (2.8)
Trunk Fat Mass (kg)	21.8^{a} (5.1)	13.6^{b} (6.3)	9.9^{c} (3.1)	8.7^{cd} (3.0)	6.7^{de} (2.8)	4.8^{e} (1.5)	5.4^{e} (2.0)	7.5^{cde} (2.7)	8.6^{cd} (3.1)
Legs Lean Mass (kg)	33.1^{a} (3.0)	32.7^{a} (3.3)	29.1^{b} (2.8)	28.4^{b} (2.3)	27.9^{b} (2.7)	25.8^{c} (2.4)	25.2^{c} (2.7)	25.8^{c} (2.9)	24.4^{c} (2.7)
Legs Fat Mass (kg)	13.2^{a} (3.1)	10.5^{b} (3.9)	7.5^{c} (1.9)	6.9^{c} (2.1)	5.2^{de} (1.8)	4.3^{e} (1.3)	4.3^{e} (1.4)	5.6^{cde} (1.5)	6.4^{cd} (2.3)
Upper/Lower Ratio	1.70^{a} (0.16)	1.56^{c} (0.12)	1.68^{ab} (0.11)	1.64^{ab} (0.12)	1.61^{abc} (0.11)	1.61^{bc} (0.11)	1.68^{ab} (0.11)	1.73^{a} (0.15)	1.72^{a} (0.13)
TULLR	2.44^{a} (0.22)	2.13^{bc} (0.24)	2.19^{b} (0.16)	2.12^{bcd} (0.18)	2.0^{de} (0.15)	1.97^{e} (0.15)	2.04^{cde} (0.18)	2.18^{b} (0.22)	2.25^{b} (0.18)
LULLR	1.59^{c} (0.12)	1.56^{c} (0.12)	1.70^{ab} (0.10)	1.67^{ab} (0.11)	1.64^{bc} (0.08)	1.67^{ab} (0.11)	1.70^{ab} (0.11)	1.75^{a} (0.15)	1.75^{a} (0.10)
GLR	0.45^{cd} (0.03)	0.44^{d} (0.03)	0.47^{abc} (0.03)	0.46^{bc} (0.03)	0.46^{bcd} (0.03)	0.46^{bc} (0.04)	0.47^{ab} (0.03)	0.47^{abc} (0.04)	0.49^{a} (0.03)
VAT (g)	811^{a} (499)	645^{ab} (481)	228^{c} (142)	241^{c} (184)	181^{c} (129)	204^{c} (144)	223^{c} (116)	248^{bc} (123)	331^{bc} (94)

For each row, if a position does not share a letter it is significantly different at an adjusted ($p<0.05$),

ULR = upper total mass (arms+trunk for fat, bone, lean mass) to total legs mass (fat, bone, lean mass) ratio, TULLR = total upper to lean legs ratio, LULLR = Lean upper to lean legs mass ratio, GLR = gynoid (glute) lean mass to lean leg mass ratio, VAT= visceral adipose tissue, OL= offensive Line, DL = defensive line, TE = tight end, LB = linebacker, RB= running back, DB = defensive back, WR = wide receiver, QB = Quarterback, ST= special teams

Table 4

Ranges of Positional Body Composition Characteristics

	OL (n=83)	DL (n=53)	TE (n=30)	LB (n=58)	RB (n=36)	DB (n=78)	WR (n=75)	QB (n=23)	ST (n=31)
Percent Fat (%)	19–41	12–37	13–28	7–28	8–27	8–22	7–21	9–25	8–29
Total Lean Mass (kg)	73–106	72–103	66–100	68–94	63–91	60–83	55–88	63–87	60–87
Total Fat Mass (kg)	18–66	12–50	13–34	6–29	7–28	6–18	6–20	7–25	6–29
Trunk Lean Mass (kg)	30–47	32–44	30–47	29–43	28–40	28–39	25–39	29–40	28–39
Trunk Fat Mass (kg)	8–36	4–27	6–17	3–17	3–17	2–8	2–11	3–14	3–14
Legs Lean Mass (kg)	23–40	27–43	23–36	24–33	23–33	20–31	19–33	20–30	21–33
Legs Fat Mass (kg)	7–22	5–21	5–12	2–12	2–7	2–9	2–8	3–8	2–13
Upper/Lower Ratio	1.34–2.10	1.34–1.80	1.43–1.87	1.40–1.99	1.42–1.84	1.36–1.81	1.47–1.93	1.51–2.09	1.49–1.93
TULLR	1.78–2.97	1.68–2.74	1.90–2.58	1.78–2.67	1.72–2.44	1.57–2.43	1.69–2.48	1.84–2.68	1.79–2.54
LULLR	1.32–1.93	1.30–1.79	1.50–1.90	1.49–1.91	1.49–1.82	1.41–1.89	1.47–1.94	1.49–2.16	1.50–1.97
GLR	0.37–0.53	0.38–0.51	0.40–0.54	0.38–0.56	0.40–0.52	0.38–0.54	0.40–0.56	0.40–0.54	0.40–0.54
VAT (g)	250–2171	78–1332	59–497	–567	3–380	–486	2–491	8–429	181–456

For each row, if a position does not share a letter it is significantly different at an adjusted ($p<0.05$),

ULR = upper total mass (arms+trunk for fat, bone, lean mass) to total legs mass (fat, bone, lean mass), TULLR = total upper to lean legs ratio, LULLR = Lean upper to lean legs mass ratio, GLR = gynoid (glute) lean mas to lean leg mass ratio, VAT= visceral adipose tissue, OL= offensive Line, DL = defensive line, TE = tight end, LB = linebacker, RB= running back, DB = defensive back, WR = wide receiver, QB = Quarterback, ST= special teams

Table 5

Total and Regional Bone Mineral Density Positional Characteristics mean(±SD)

	OL (n=83)	**DL (n=53)**	**TE (n=30)**	**LB (n=58)**	**RB (n=36)**	**DB (n=78)**	**WR (n=75)**	**QB (n=23)**	**ST (n=31)**
Total BMD (g/cm^2)	1.63^{ab} (0.12)	1.65^{a} (0.11)	1.59^{abc} (0.11)	1.61^{ab} (0.10)	1.56^{bcd} (0.12)	1.54^{cd} (0.11)	1.51^{cd} (0.10)	1.56^{bcd} (0.13)	1.47^{d} (0.10)
Total BMD z-score	3.4^{a} (1.1)	3.3^{a} (0.8)	3.0^{ab} (1.0)	2.9^{ab} (0.8)	2.8^{ab} (1.1)	2.4^{b} (0.9)	2.1^{b} (0.7)	2.1^{b} (0.8)	2.4^{ab} (0.8)
Total Less Head BMD (g/cm^2)	1.48^{a} (0.12)	1.49^{a} (0.11)	1.44^{ab} (0.12)	1.45^{ab} (0.11)	1.40^{abc} (0.13)	1.39^{bc} (0.10)	1.38^{bc} (0.10)	1.39^{bc} (0.14)	1.31^{c} (0.11)
Legs BMD (g/cm^2)	1.78^{ab} (0.13)	1.81^{a} (0.12)	1.74^{abcd} (0.12)	1.74^{abc} (0.12)	1.72^{bcde} (0.13)	1.70^{cde} (0.13)	1.66^{de} (0.13)	1.65^{de} (0.14)	1.62^{e} (0.10)
Spine BMD (g/cm^2)	1.57^{a} (0.16)	1.60^{a} (0.16)	1.51^{abc} (0.15)	1.54^{ab} (0.11)	1.47^{bc} (0.13)	1.45^{bc} (0.13)	1.42^{c} (0.13)	1.45^{bc} (0.14)	1.39^{c} (0.13)

For each row, if a position does not share a letter it is significantly different at an adjusted ($p<0.05$),

BMD = bone mineral density, Total Less Head = BMD minus the head, OL= offensive Line, DL = defensive line, TE = tight end, LB = linebacker, RB= running back, DB = defensive back, WR = wide receiver, QB = Quarterback, ST= special teams

Table 6

Ranges of Total and Regional Bone Mineral Density by Position

	OL (n=83)	**DL (n=53)**	**TE (n=30)**	**LB (n=58)**	**RB (n=36)**	**DB (n=78)**	**WR (n=75)**	**QB (n=23)**	**ST (n=31)**
Total BMD (g/cm^2)	1.42–2.11	1.43–1.93	1.42–1.84	1.42–1.86	1.28–1.74	1.30–1.86	1.26–1.85	1.34–1.84	1.31–1.66
Total Less Head BMD (g/cm^2)	1.27–1.77	1.30–1.83	1.24–1.64	1.28–1.70	1.04–1.62	1.19–1.84	1.20–1.67	1.21–1.75	1.17–1.55
Legs BMD (g/cm^2)	1.53–2.30	1.58–2.18	1.56–2.05	1.55–2.03	1.44–1.94	1.37–2.04	1.38–2.0	1.48–2.04	1.38–1.78
Spine BMD (g/cm^2)	1.32–2.35	1.39–2.14	1.24–1.79	1.28–1.82	1.07–1.71	1.19–1.84	1.16–1.83	1.29–1.77	1.21–1.65

BMD = bone mineral density, Total Less Head = BMD minus the head, OL= offensive Line, DL = defensive line, TE = tight end, LB = linebacker, RB= running back, DB = defensive back, WR = wide receiver, QB = Quarterback, ST= special teams