Longitudinal Assessment of NCAA Division I Football Body Composition by Season and Player Age

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Abstract

Wichmann, TK, Wolfson, J, Roelofs, EJ, Bosch, TA, Bach, CW, Oliver, JM, Carbuhn, A, Stanforth, PR, and Dengel, DR. Longitudinal assessment of NCAA Division I football body composition by season and player age. *J Strength Cond Res* 36(6): 1682–1690, 2022—The purpose of this study was to examine longitudinal body composition changes by position, categorized by season and age, using dual X-ray absorptiometry in NCAA Division I football players. Seven hundred nineteen collegiate male football players aged 18–22 years ($\bar{X}_{age} \pm SE = 19.4 \pm 0.05$ years) were examined. Percent body fat (%BF), fat mass (FM), lean mass (LM), total body mass (TM), bone mineral density (BMD), and visceral adipose tissue (VAT) were measured. Players were categorized into position groups of Linemen, Big Skill, Skill, or Special Team. One player scan was used per season (preseason, postseason, and spring season). Analysis of variance and Tukey HSD assessed total and regional differences across age, position groups, and seasons (significance of $p < 0.05$). Linemen had the greatest FM and LM measures compared with other groups for season and age. From preseason to postseason, %BF, FM, LM, and BMD significantly decreased for each position group. From post-season to spring season, %BF, FM, and VAT decreased, whereas LM increased within each position group. FM, VAT, LM, and TM increased with age in all position groups. The findings of this study indicate that body composition significantly worsened from preseason to postseason and improved from the preseason and postseason to the spring season.

Key Words: dual X-ray absorptiometry, athletes, body fat percentage, lean mass, fat mass

Introduction

American football is a unique sport in that it has well-defined positions on both offense and defense. Each of these positions have different physical demands that often require a particular body type to be successful (7,8,15–17). In general, most athletes are trying to maximize their lean muscle mass (LM) while keeping their fat mass (FM) low; however, the optimal total body mass (TM) for each position is highly variable (5,6,9).

Previously, using dual X-ray absorptiometry (DXA), we reported positional differences in both total and regional body composition in professional and collegiate football players (5,6,9). In both professional and collegiate football players, we observed that offensive and defensive positions that mirror each other have similar body composition characteristics (6,9). In both collegiate and professional football players, the offensive and defensive linemen not only have more TM but also had a greater percent FM than other positions (6,9). Although wide receivers and defensive backs had the lowest TM and the lowest percent FM, tight ends, linebackers, and running backs fell in between these offensive and defensive position groups (6,9).

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Somewhat unique to collegiate football is the general expectation that a majority of players will increase in size over their collegiate career. The goal is often to increase TM, with a majority of that gain coming in the form of LM. For some athletes, such as offensive and defensive linemen, this goal is complicated by the fact that FM accumulates at a greater proportion per pound in those football players who weigh above 250 pounds (5). This additional FM also results in an exponential increase visceral abdominal fat tissue (VAT) (5). In addition to increased injury risk (18,19), VAT is an independent risk factor for cardiovascular disease and insulin resistance (10,11,13,20,24).

In addition to the yearly body composition goals, there are expectations during each season regarding changes in body composition. Expectations include minimizing the decrease in LM that can occur during the competitive season (3) while increasing TM and LM during the off-season. Managing body composition to meet the demands of their position and sport presents a unique challenge for the sports performance staff.

Although seasonal and yearly changes by position as well as year of eligibility have been examined by previous studies (3,4,12,23,26), the sample size of these studies is small, leading to potential inaccuracies. In addition, none of these studies examined changes in body composition by age within and among position groups. To date, no study has examined longitudinal body composition changes in collegiate football players by position and age. Based on the goals of most collegiate football programs, one could hypothesize that there would be a steady increase in TM and LM over a player's collegiate career. Thus, the aims of this study are 2-fold: (a) to determine if body composition significantly changes with playing season, within and between position groups; and (b) to determine if body composition significantly changes with player age within position groups.

Methods

Experimental Approach to the Problem

Data from this study were obtained from football players scanned between 2008 and 2018 from 5 different NCAA Division I Universities. Each player had height, mass, and total and regional body composition measured at each scan. Subjects were instructed to maintain hydration levels and abstain from eating and caffeine 4 hours before their DXA scan. Scans were completed at least 2 hours before a practice session or on rest days. Football seasons were defined as preseason, postseason, and spring season. Each player was categorized into 1 of 4 position groups: Linemen, Big Skill, Skill, and Special Team. Total and regional body composition differences were analyzed across age, position groups, and seasons for percent body fat (%BF), LM, FM, TM, bone mineral density (BMD), VAT, and mass distribution ratios. Only one scan per player was used for each season within a year, and if a player received more than one scan during a season in a given year, their scans were randomized and only one scan was analyzed.

Subjects

Seven hundred nineteen collegiate male football players, aged 18–22 years, from 5 different NCAA Division I Universities participated in the study. Each player was categorized into 1 of 4 position groups: Linemen (offensive and defensive linemen), Big Skill (linebackers, tight ends, quarterbacks), Skill (defensive backs, running backs, wide receivers), and Special Team (punters, kickers, long snappers). Each player gave written informed consent before participation. Approval for retrospective statistical analysis of preexisting DXA scan data was given by each University's (i.e., University of Minnesota, University of Texas, University of Kansas, University of Nebraska, Texas Christian University) Institutional Review Board.

Procedures

All players were scanned between 2008 and 2018 at their respective University. Total and regional body composition was measured using standard procedures (GE Healthcare Lunar) in the total-body supine position on a GE Lunar iDXA or Prodigy (General Electric Medical Systems, Madison, WI) after measurement of height and weight. DXA scan files from all participating Universities were sent to the author's University for analysis. The same technician analyzed all scans using enCore software (platform version 16.2; General Electric Medical Systems). Regional body composition was measured using automatically created region of interest boxes, and VAT mass was measured using CoreScan (General Electric Medical Systems). Mass distribution ratios were calculated, including gynoid lean mass to leg lean mass ratio (GLR), upper total mass to legs total mass ratio (ULR), total upper mass to lean leg mass ratio (TULLR), and lean upper mass to lean leg mass ratio (LULLR). Upper body includes left and right arm masses and the trunk, and total mass includes lean soft tissue, FM, and bone mass for all ratios.

For this study, the football seasons were defined as preseason (June to September), postseason (December to February), and spring season (March to May). Only one scan per player was used for each season within a year, and if a player received more than one scan during a season in a given year, their scans were randomized and only one scan was analyzed. Further, if players were assigned more than one position in a season across their career, they were not included in analysis.

Statistical Analyses

One-way analysis of variance (ANOVA) with Tukey HSD (honest significant difference) post hoc tests assessed differences between position groups (significance of $p \leq 0.05$). Separate repeated ANOVAs with linear mixed-effects models assessed total and regional body composition differences across age, position groups, and seasons for %BF, LM, FM, TM, BMD, VAT, GLR, ULR, TULLR, and LULLR. Tukey HSD post hoc tests were used to determine significant differences among position groups while adjusting for multiple comparisons (significance of $p \leq 0.05$). R software (R Foundation for Statistical Computing, Vienna, Austria) was used to conduct all statistical analyses.

Results

Descriptive Characteristics

Descriptive characteristics for each position group are presented in Table 1. With all seasons combined, age did not differ significantly between position groups. Linemen were significantly taller ($p < 0.001$) and had greater TM, BMI, %BF, LM, and FM ($p < 0.001$) than Big Skill, Skill, and Special Team players. Big Skill players were significantly taller ($p < 0.01$) and had greater TM, BMI, and LM ($p < 0.001$) than Skill and Special Team players. Big Skill and Special Team players had significantly greater %BF and FM ($p < 0.001$) than Skill players. Skill players had significantly greater LM ($p < 0.04$) than Special Team players. Special Team players were significantly taller ($p < 0.01$) and had greater TM ($p < 0.04$) and %BF ($p < 0.001$) than Skill players.

Positional Differences Within Seasons

Positional differences within each season are reported in Table 2. Linemen had significantly greater TM, %BF, FM, LM, BMD, and VAT compared with Big Skill, Skill, and Special Team players in each season ($p < 0.001$). Big Skill players had significantly greater TM and LM compared with Skill and Special Team players in each season ($p < 0.001$). Big Skill and Special Team players had significantly greater %BF and FM compared with Skill players in each season ($p < 0.001$). Big Skill had significantly greater BMD compared with Skill ($p = 0.003$) and Special Team players ($p < 0.001$), and Skill players had significantly greater BMD compared with Special Team players in each season ($p = 0.009$).

Positional differences for body composition ratios within each season are reported in Table 3. Linemen and Special Team players had significantly higher TULLR compared with Big Skill and Skill players ($p < 0.01$), whereas Big Skill players had significantly higher TULLR than Skill players ($p < 0.001$) in each season. Linemen had significantly lower LULLR and GLR compared with Big Skill, Skill,

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Table 1

Descriptive characteristics of study subjects (mean ± *SE*).*†

	Linemen	Big Skill	Skill	Special Teams	Total	95% Confidence interval
Number of scans	780	597	873	154	2,404	
Number of athletes	207	177	282	53	719	
Age (y)	19.4 ± 0.1	19.4 ± 0.1	19.4 ± 0.1	19.6 ± 0.2	19.4 ± 0.05	19.2–20.0
Ethnicity (n, %)						
Black	101 (48.8%)	72 (40.7%)	176 (62.4%)	2 (3.77%)	351 (48.8%)	
Hispanic	7 (3.38%)	1 (0.565%)	3 (1.06%)	0 (0.0%)	11 (1.5%)	
White	96 (46.4%)	102 (57.6%)	99 (35.1%)	49 (92.5%)	346 (48.1%)	
Other	3 (1.45%)	2 (1.13%)	4 (1.42%)	2 (3.77%)	11 (1.5%)	
Total mass (kg)	128.9 ± 0.7[a]	101.9 ± 0.8[b]	88.2 ± 0.6[c]	91.3 ± 1.5[d]	103.0 ± 0.7	88.2–129.8
Height (m)	1.91 ± 0.004[a]	1.87 ± 0.004[b]	1.81 ± 0.003[c]	1.84 ± 0.007[d]	1.9 ± 0.002	1.8–1.9
BMI ($kg\cdot m^{-2}$)	35.3 ± 0.2[a]	29.3 ± 0.2[b]	26.8 ± 0.2[c]	27.0 ± 0.4[c]	29.9 ± 0.2	26.2–27.2
Percent body fat (%)	27.0 ± 0.3[a]	18.6 ± 0.4[b]	14.2 ± 0.3[c]	19.7 ± 0.7[b]	19.4 ± 0.3	13.6–27.7
Total fat mass (kg)	34.9 ± 0.5[a]	18.9 ± 0.5[b]	12.5 ± 0.4[c]	18.1 ± 1.0[b]	21.0 ± 0.4	11.7–20.0
Total lean mass (kg)	88.5 ± 0.4[a]	78.9 ± 0.5[b]	72.2 ± 0.4[c]	69.7 ± 0.9[b]	78.4 ± 0.4	68.0–90.0

*BMI = body mass index; n, % = number of athletes, percentage of athletes.
†Different letters denote significant differences ($p < 0.05$) between position groups.

Table 2

Positional differences within each season for body composition variables and composition changes within each position over the competitive seasons (mean ± *SE*).*†

Variable	Season: Pre	Season: Post	Season: Spring	Season differences *p*	Season confidence interval 95%	Position differences *p*	Position confidence interval 95%
Total mass (kg)				>0.05	102–104	<0.001	89.5–131
Linemen[a]	129.9 ± 0.7	129.6 ± 0.7	129.4 ± 0.7				
Big Skill[b]	102.2 ± 0.8	101.9 ± 0.8	101.7 ± 0.8				
Skill[c]	88.6 ± 0.6	88.3 ± 0.6	88.1 ± 0.6				
Special Team[c]	91.9 ± 1.4	91.7 ± 1.4	91.5 ± 1.4				
Percent body fat (%)				<0.001	19.1–20.7	<0.001	13.7–27.7
Linemen[a]	27.2 ± 0.3	27.4 ± 0.3	26.7 ± 0.3‡				
Big Skill[b]	18.6 ± 0.3	18.9 ± 0.4	18.1 ± 0.4‡				
Skill[c]	14.4 ± 0.3	14.6 ± 0.3	13.9 ± 0.3‡				
Special Team[b]	20.0 ± 0.6	20.2 ± 0.6	19.5 ± 0.6‡				
Total fat mass (kg)				<0.001	20.05–22.12	<0.001	11.82–35.89
Linemen[a]	35.19 ± 0.46	35.33 ± 0.46	34.49 ± 0.47‡				
Big Skill[b]	18.97 ± 0.49	19.11 ± 0.50	18.28 ± 0.50‡				
Skill[c]	12.77 ± 0.40	12.92 ± 0.40	12.08 ± 0.41‡				
Special Team[b]	18.54 ± 0.91	18.68 ± 0.91	17.84 ± 0.91‡				
Total lean mass (kg)				<0.001	76.60–78.40	<0.001	68.09–89.86
Linemen[a]	89.08 ± 0.44	88.63 ± 0.44‡	89.28 ± 0.44				
Big Skill[b]	79.15 ± 0.48	78.70 ± 0.48‡	79.35 ± 0.48				
Skill[c]	72.39 ± 0.38	71.95 ± 0.38‡	72.60 ± 0.38				
Special Team[c]	69.87 ± 0.87	69.42 ± 0.87‡	70.07 ± 0.87				
BMD ($g\cdot cm^{-2}$)				<0.04	1.56–1.59	<0.001	1.46–1.52
Linemen[a]	1.67 ± 0.01§	1.66 ± 0.01§	1.67 ± 0.01				
Big Skill[b]	1.59 ± 0.01§	1.59 ± 0.01§	1.59 ± 0.01				
Skill[c]	1.55 ± 0.01§	1.55 ± 0.01§	1.55 ± 0.01				
Special Team[d]	1.49 ± 0.02§	1.48 ± 0.02§	1.49 ± 0.02				
VAT (kg)				<0.02	0.41–0.51	<0.001	0.24–0.93
Linemen[a]	0.89 ± 0.02	0.90 ± 0.02§	0.87 ± 0.02§				
Big Skill[b]	0.34 ± 0.03	0.35 ± 0.03§	0.31 ± 0.03§				
Skill[b]	0.28 ± 0.02	0.29 ± 0.02§	0.26 ± 0.02§				
Special Team[b]	0.36 ± 0.05	0.37 ± 0.05§	0.33 ± 0.05§				

*BMD = bone mineral density; VAT = visceral adipose tissue.
†Different letters denote a significant difference ($p < 0.05$) between position groups within each season and the *p*-value is labeled by positional difference.
‡Denotes significantly different from all other seasons ($p < 0.05$).
§Denotes significantly different from seasons without a symbol ($p < 0.05$).

Table 3

Positional differences within each season for body composition ratios and changes within each position over the competitive seasons (mean ± *SE*).*†

Variable	Season: Pre	Season: Post	Season: Spring	Season differences *p*	Season confidence interval 95%	Position differences *p*	Position confidence interval 95%
TULLR				>0.05	2.17–2.22	<0.001	2.02–2.36
Linemen[a]	2.33 ± 0.01	2.33 ± 0.01	2.33 ± 0.01				
Big Skill[b]	2.15 ± 0.01	2.15 ± 0.01	2.14 ± 0.02				
Skill[c]	2.04 ± 0.01	2.04 ± 0.01	2.04 ± 0.01				
Special Team[a]	2.27 ± 0.03	2.28 ± 0.03	2.27 ± 0.03				
LULLR				>0.05	1.66–1.70	<0.01	1.57–1.78
Linemen[a]	1.59 ± 0.01	1.58 ± 0.01	1.60 ± 0.01				
Big Skill[b]	1.68 ± 0.01	1.68 ± 0.01	1.68 ± 0.01				
Skill[b]	1.69 ± 0.01	1.68 ± 0.01	1.70 ± 0.01				
Special Team[c]	1.75 ± 0.02	1.74 ± 0.02	1.75 ± 0.02				
ULR				<0.02	1.90–1.97	<0.01	1.80–2.08
Linemen[a]	2.03 ± 0.02§	2.00 ± 0.02§	2.01 ± 0.02				
Big Skill[b]	1.91 ± 0.02§	1.88 ± 0.02§	1.89 ± 0.02				
Skill[b]	1.84 ± 0.01§	1.81 ± 0.01§	1.82 ± 0.01				
Special Team[a]	2.03 ± 0.03§	2.00 ± 0.03§	2.01 ± 0.03				
GLR				<0.001	0.46–0.47	<0.001	0.44–0.49
Linemen[a]	0.45 ± 0.002	0.44 ± 0.002‡	0.45 ± 0.002				
Big Skill[b]	0.46 ± 0.002	0.46 ± 0.002‡	0.46 ± 0.002				
Skill[b]	0.47 ± 0.002	0.46 ± 0.002‡	0.47 ± 0.002				
Special Team[c]	0.49 ± 0.004	0.48 ± 0.004‡	0.49 ± 0.004				

*TULLR = total upper mass to lean leg mass ratio; LULLR = lean upper mass to lean leg mass ratio; ULR = upper total mass to legs total mass ratio; GLR = gynoid lean mass to leg lean mass ratio.
†Different letters denote a significant difference between position groups within each season and the *p*-value is labeled by position difference.
‡Denotes significantly different from all other seasons ($p < 0.05$).
§Denotes significantly different from seasons without a symbol ($p < 0.05$).

and Special Team players ($p < 0.001$), whereas Big Skill players had significantly lower LULLR ($p = 0.021$) and GLR ($p < 0.001$) than Special Team players in each season. Skill players had significantly lower LULLR ($p = 0.041$) and GLR ($p = 0.003$) than Special Team players in each season. Linemen and Special Team players had significantly higher ULR compared with Big Skill ($p \leq 0.05$) and Skill players ($p < 0.001$) in each season.

Body Composition Changes Over a Competitive Year

Seasonal differences within each position are reported in Table 2. Percent body fat and FM (Figure 1, Panel C) decreased significantly from preseason to spring season and from postseason to spring season in all position groups ($p < 0.001$). LM decreased significantly from preseason to postseason and increased from postseason to spring season in all position groups ($p < 0.001$; Figure 1, Panel B). Visceral adipose tissue mass decreased significantly from postseason to spring season in all position groups ($p = 0.004$). BMD significantly decreased from preseason to postseason ($p = 0.029$) in all position groups. No significant changes were observed for TM across seasons in all position groups ($p > 0.05$; Figure 1, Panel A).

Seasonal differences for body composition ratios within each position are reported in Table 3. ULR decreased significantly from preseason to postseason in all position groups ($p = 0.0001$). GLR decreased significantly from preseason to postseason ($p = 0.017$) and increased from postseason to spring season ($p = 0.01$) in all position groups.

Body Composition Changes Over Player Age

Age differences for changes in body composition within each position are reported in Table 4. TM (Figure 2, panel A) was significantly different at age 18 years from age 19, 20, 21, and 22 years ($p < 0.001$) and were significantly different at age 19 years from 20, 21, and 22 years ($p < 0.01$) in all position groups. TM also increased from age 20 to 22 years ($p < 0.01$) in all position groups. LM (Figure 2, panel B) was significantly different at age 18 years from age 19, 20, 21, and 22 years ($p < 0.001$) and were significantly different at age 19 years from 20, 21, and 22 years ($p < 0.01$) in all position groups. LM also increased from age 20 to 22 years ($p < 0.01$) in all position groups. VAT was significantly different from age 18 years to age 20, 21, and 22 years ($p < 0.001$) and were significantly different at age 19 years from age 20, 21, and 22 years ($p < 0.001$) in all position groups. Visceral adipose tissue also increased from age 20 to 22 years ($p < 0.01$) in all position groups. FM increased significantly from age 18 to 21 years ($p = 0.01$) and from age 18 to 22 years ($p = 0.01$; Figure 2, Panel C) in all position groups. BMD at each year of age was significantly different from each year of age ($p < 0.05$) in all position groups.

Age differences for body composition ratios within each position are reported in Table 5. TULLR increased significantly from ages 18 to 21 years ($p = 0.025$) and from 18 to 22 years ($p = 0.024$) in all position groups. Gynoid lean mass to leg lean mass ratio was significantly different at age 18 years from age 19, 20, 21, and 22 years ($p < 0.01$) and were

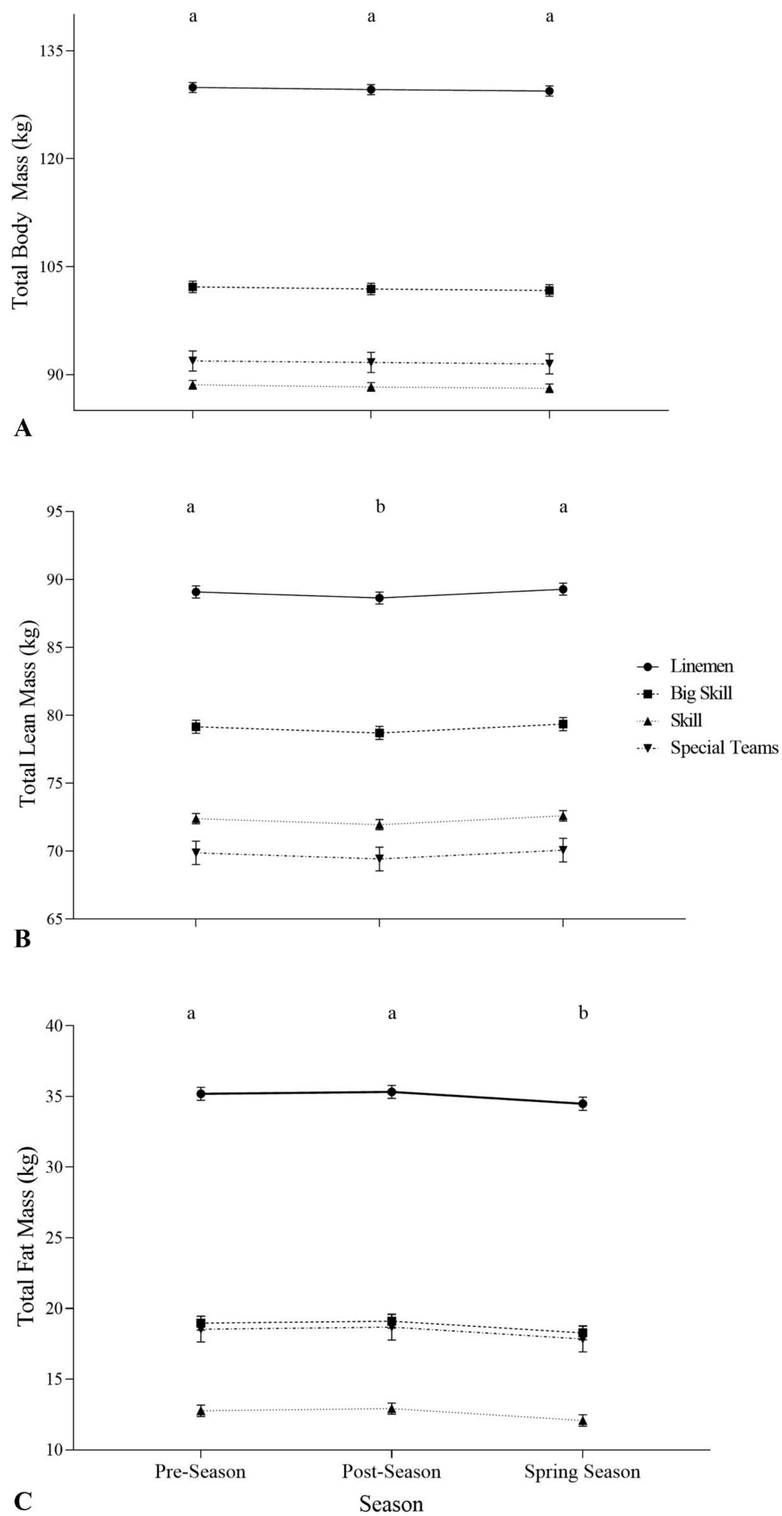

Figure 1. Comparison of position groups across seasons for total body mass (panel A), total lean soft tissue mass (panel B), and total fat mass (panel C). Different letters denote significant differences ($p < 0.001$) between seasons within position groups. All values are reported as mean ± *SE*.

significantly different at age 19 years from age 20, 21, and 22 years ($p < 0.02$) in all position groups. Upper total mass to legs total mass ratio decreased significantly from ages 18 to 21 years ($p < 0.001$) and from 18 to 22 years ($p < 0.001$) in all position groups. Further, ULR was significantly different at age 19 years from age 20, 21, and 22 years ($p < 0.01$) and were significantly different at age 20 years from age 21 and 22 years ($p < 0.01$) in all position groups.

Table 4
Body composition changes within each position over player age (mean ± *SE*).*†

Variable	Age (y) 18	19	20	21	22	Age difference *p*	Confidence interval 95%
Total mass (kg)						<0.01	99.7–106.0
Linemen	127.3 ± 0.7[a]	129.0 ± 0.7[b]	130.1 ± 0.7[c]	130.9 ± 0.7[cd]	131.5 ± 0.7[d]		
Big Skill	99.9 ± 0.8[a]	101.7 ± 0.8[b]	102.7 ± 0.8[c]	103.5 ± 0.8[cd]	104.1 ± 0.8[d]		
Skill	86.2 ± 0.6[a]	88.0 ± 0.6[b]	89.0 ± 0.6[c]	89.8 ± 0.6[cd]	90.4 ± 0.7[d]		
Special Team	89.3 ± 1.4[a]	91.0 ± 1.4[b]	92.1 ± 1.4[c]	92.9 ± 1.4[cd]	93.5 ± 1.4[d]		
Percent body fat (%)						>0.05	19.0–20.8
Linemen	26.6 ± 0.3	27.0 ± 0.3	27.0 ± 0.3	27.3 ± 0.3	27.4 ± 0.4		
Big Skill	18.1 ± 0.4	18.6 ± 0.4	18.5 ± 0.4	18.8 ± 0.4	18.9 ± 0.4		
Skill	13.8 ± 0.3	14.3 ± 0.3	14.2 ± 0.3	14.5 ± 0.3	14.7 ± 0.3		
Special Team	19.4 ± 0.7	19.8 ± 0.6	19.8 ± 0.6	20.0 ± 0.6	20.2 ± 0.7		
Total fat mass (kg)						<0.03	19.8–22.5
Linemen	34.2 ± 0.5[a]	34.9 ± 0.5[ab]	34.9 ± 0.5[ab]	35.3 ± 0.5[b]	35.5 ± 0.5[b]		
Big Skill	18.1 ± 0.5[a]	18.8 ± 0.5[ab]	18.8 ± 0.5[ab]	19.2 ± 0.5[b]	19.4 ± 0.5[b]		
Skill	11.9 ± 0.4[a]	12.6 ± 0.4[ab]	12.6 ± 0.4[ab]	13.0 ± 0.4[b]	13.2 ± 0.4[b]		
Special Team	17.6 ± 0.9[a]	18.2 ± 0.9[ab]	18.3 ± 0.9[ab]	18.6 ± 0.9[b]	18.9 ± 0.9[b]		
Total lean mass (kg)						<0.001	75.6–79.5
Linemen	87.6 ± 0.4[a]	88.5 ± 0.4[b]	89.5 ± 0.4[c]	89.9 ± 0.4[cd]	90.3 ± 0.5[d]		
Big Skill	77.8 ± 0.5[a]	78.7 ± 0.5[b]	79.8 ± 0.5[c]	80.1 ± 0.5[cd]	80.5 ± 0.5[d]		
Skill	71.0 ± 0.4[a]	71.9 ± 0.4[b]	72.9 ± 0.4[c]	73.3 ± 0.4[cd]	73.7 ± 0.4[d]		
Special Team	68.3 ± 0.9[a]	69.3 ± 0.9[b]	70.3 ± 0.9[c]	70.6 ± 0.9[cd]	71.0 ± 0.9[d]		
BMD ($g \cdot cm^{-2}$)						<0.01	1.51–1.63
Linemen	1.61 ± 0.01[a]	1.65 ± 0.01[b]	1.68 ± 0.01[c]	1.69 ± 0.01[d]	1.71 ± 0.01[e]		
Big Skill	1.54 ± 0.01[a]	1.58 ± 0.01[b]	1.61 ± 0.01[c]	1.63 ± 0.01[d]	1.64 ± 0.01[e]		
Skill	1.50 ± 0.01[a]	1.54 ± 0.01[b]	1.57 ± 0.01[c]	1.58 ± 0.01[d]	1.60 ± 0.01[e]		
Special Team	1.43 ± 0.01[a]	1.47 ± 0.01[b]	1.50 ± 0.01[c]	1.52 ± 0.01[d]	1.53 ± 0.01[e]		
VAT (kg)						<0.03	0.34–0.58
Linemen	0.79 ± 0.03[a]	0.84 ± 0.02[a]	0.89 ± 0.02[b]	0.92 ± 0.02[bc]	0.96 ± 0.03[c]		
Big Skill	0.25 ± 0.03[a]	0.30 ± 0.03[a]	0.35 ± 0.03[b]	0.38 ± 0.03[bc]	0.42 ± 0.03[c]		
Skill	0.19 ± 0.02[a]	0.24 ± 0.02[a]	0.29 ± 0.02[b]	0.32 ± 0.02[bc]	0.36 ± 0.02[c]		
Special Team	0.26 ± 0.05[a]	0.30 ± 0.05[a]	0.36 ± 0.05[b]	0.39 ± 0.05[bc]	0.43 ± 0.05[c]		

*BMD = bone mineral density; VAT = visceral adipose tissue.
†Different letters denote a significant difference ($p < 0.05$) between age within each position group and the *p*-value is labeled by age difference.

Discussion

To our knowledge, this is the first study to examine longitudinal changes in body composition determined by DXA in NCAA Division I football players by season, position, and player age. The results of this study indicate that out of the 4 position groups, the Linemen had the highest %BF, FM, VAT, LM, TM, and BMD ($p < 0.001$) across each season and age, which agrees with previous literature (6,9,23,25). Of interest, LM and BMD decreased from the preseason to the postseason, and LM increased from the postseason to the spring season for all position groups. Further, %BF and FM decreased from the preseason and postseason to the spring season in addition to a decrease in VAT from the postseason to the spring season for all position groups. Finally, there was an increase in FM, VAT, LM, TM, and BMD with each year of age within each position group, but there were no changes in %BF.

To date, longitudinal changes in VAT mass in collegiate and professional football players has not been explored. In the current study, VAT mass decreased significantly from the postseason to spring season in all position groups. These findings suggest that in these athletes, the training program in the postseason decreased abdominal obesity. LM and BMD significantly decreased from preseason to postseason; however, significant increases were observed for LM from postseason to spring season for all position groups. The decreases observed in LM from preseason to postseason agrees with the results from Binkley et al. (3) who observed a 1.4-kg decrease in LM, but disagrees with Trexler et al. (26) and Bolonchuk and Lukaski (4) who observed a 0.9-kg increase and a 0.4-kg increase, respectively, in LM from the preseason to postseason. The observed increases in LM from postseason to spring season may be because of a training program that focuses on heavy weight training and increasing LM in the postseason versus during the regular season where the training program focuses more on technique and skill to improve player performance (26). However, there still remains a possibility that the observed discrepancies between previous research and this study might be because of varied sample sizes and differences in season and position group definitions among studies.

Over a competitive year, %BF and FM were significantly lower in the spring season compared with the preseason and postseason, with no significant changes from the pre-season to the post-season for all position groups. Previously, Bolonchuk and Lukaski (4) demonstrated a decrease in %BF from preseason to postseason; however, Binkley et al. (3) reported an increase in %BF from preseason to postseason. The differences between the present study and these previous studies may be because of differences in the definitions of preseason and postseason and differences in the definition of position groups (3,4). Bolonchuk and Lukaski (4) did not define positions or position groups and scanned their NCAA Division I collegiate players 2 days before the start of fall practice (preseason) and 13 weeks after the preseason test (postseason). Binkley et al. (3) defined

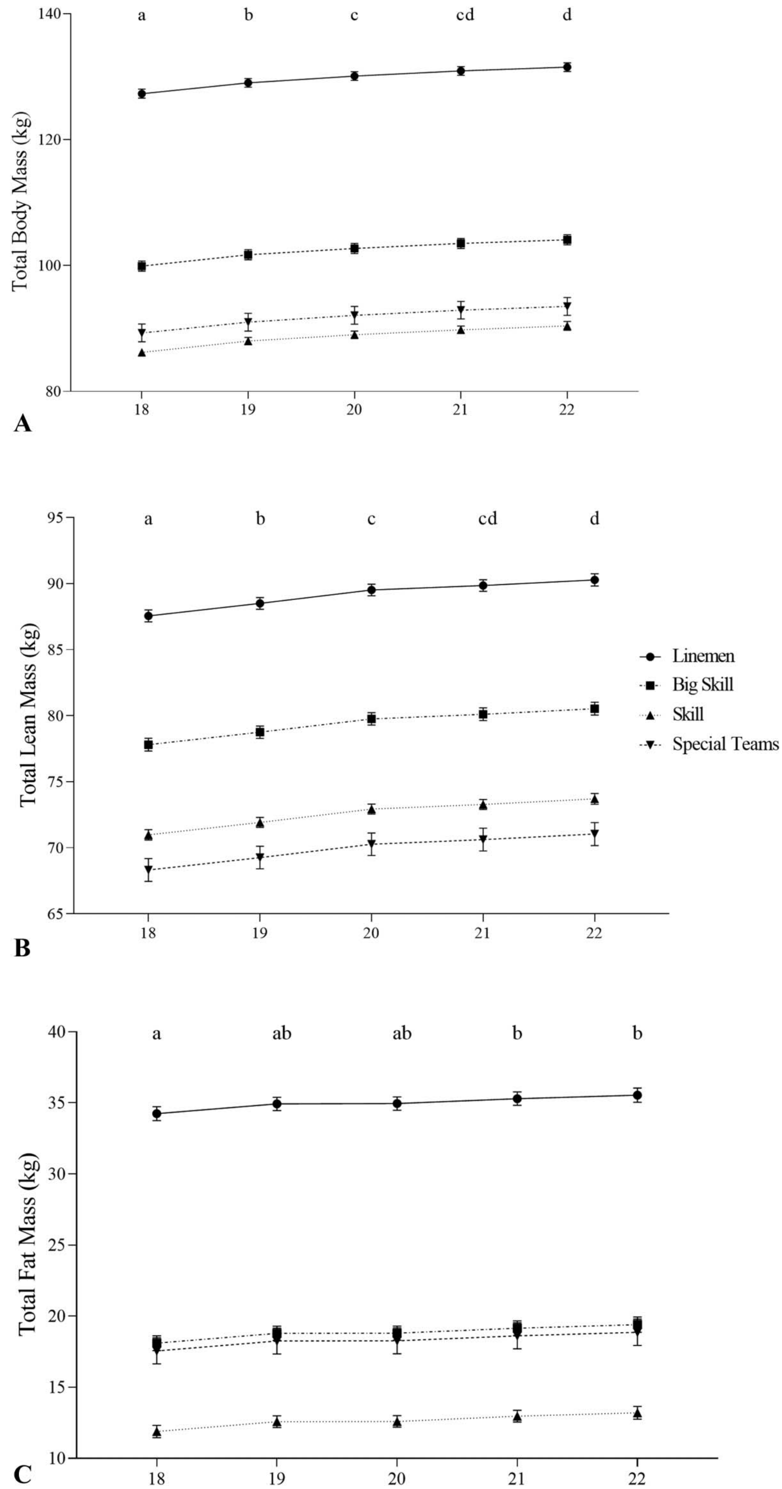

Figure 2. Comparison of position groups across ages 18–22 years for total body mass (panel A), total lean soft tissue mass (panel B), and total fat mass (panel C). Different letters denote significant differences ($p < 0.03$) between seasons within position groups. All values are reported as mean ± *SE.*

their groups as linemen and nonlinemen, and upperclassmen and underclassmen. Furthermore, preseason scans took place 1 to 2 weeks before the start of fall practice and postseason scans took place within 1 week after the last game of the season. Compared with the aforementioned studies, the present study uniquely defined 4 distinct position groups and 3 seasons, randomizing scans within each season for measurement, given the complexity of analyzing data from 5 different programs.

Longitudinal analysis of age by position group demonstrated that each body composition variable, except %BF,

Table 5
Body composition ratio changes within each position over player age (mean ± *SE*).*†

Variable	Age (y)					Age difference	Confidence interval
	18	19	20	21	22	*p*	95%
TULLR						<0.05	2.15–2.24
Linemen	2.31 ± 0.01[a]	2.33 ± 0.01[ab]	2.33 ± 0.01[ab]	2.34 ± 0.01[b]	2.35 ± 0.02[b]		
Big Skill	2.13 ± 0.02[a]	2.15 ± 0.02[ab]	2.15 ± 0.02[ab]	2.16 ± 0.02[b]	2.17 ± 0.02[b]		
Skill	2.02 ± 0.01[a]	2.04 ± 0.01[ab]	2.04 ± 0.01[ab]	2.06 ± 0.01[b]	2.06 ± 0.01[b]		
Special Team	2.25 ± 0.03[a]	2.27 ± 0.03[ab]	2.27 ± 0.03[ab]	2.29 ± 0.03[b]	2.29 ± 0.03[b]		
LULLR						>0.05	1.66–1.70
Linemen	1.58 ± 0.01	1.59 ± 0.01	1.59 ± 0.01	1.59 ± 0.01	1.59 ± 0.01		
Big Skill	1.68 ± 0.01	1.68 ± 0.01	1.69 ± 0.01	1.69 ± 0.01	1.69 ± 0.01		
Skill	1.68 ± 0.01	1.69 ± 0.01	1.69 ± 0.01	1.69 ± 0.01	1.69 ± 0.01		
Special Team	1.74 ± 0.02	1.75 ± 0.02	1.75 ± 0.02	1.75 ± 0.02	1.75 ± 0.02		
ULR						<0.001	1.85–1.98
Linemen	2.03 ± 0.02[ab]	2.04 ± 0.02[a]	2.01 ± 0.02[b]	1.98 ± 0.02[c]	1.96 ± 0.02[c]		
Big Skill	1.91 ± 0.02[ab]	1.91 ± 0.02[a]	1.89 ± 0.02[b]	1.85 ± 0.02[c]	1.83 ± 0.02[c]		
Skill	1.84 ± 0.02[ab]	1.85 ± 0.02[a]	1.82 ± 0.02[b]	1.79 ± 0.02[c]	1.77 ± 0.02[c]		
Special Team	2.04 ± 0.04[ab]	2.04 ± 0.03[a]	2.01 ± 0.03[b]	1.98 ± 0.04[c]	1.96 ± 0.04[c]		
GLR						<0.001	0.45–0.47
Linemen	0.44 ± 0.002[a]	0.44 ± 0.002[b]	0.45 ± 0.002[c]	0.45 ± 0.002[c]	0.45 ± 0.003[bc]		
Big Skill	0.45 ± 0.003[a]	0.46 ± 0.002[b]	0.47 ± 0.002[c]	0.47 ± 0.003[c]	0.47 ± 0.003[bc]		
Skill	0.46 ± 0.002[a]	0.46 ± 0.002[b]	0.47 ± 0.002[c]	0.47 ± 0.002[c]	0.47 ± 0.002[bc]		
Special Team	0.48 ± 0.005[a]	0.48 ± 0.004[b]	0.49 ± 0.004[c]	0.49 ± 0.004[c]	0.49 ± 0.005[bc]		

*TULLR = total upper mass to lean leg mass ratio; LULLR = lean upper mass to lean leg mass ratio; ULR = upper total mass to legs total mass ratio; GLR = gynoid lean mass to leg lean mass ratio.
†Different letters denote a significant difference ($p < 0.05$) between age within each position group and the *p*-value is labeled by Age Difference.

gradually increased as players' age increased within each position group. Increases in LM and BMD may be the result of strength training and position-specific training on the field, causing players to improve LM and BMD (26). Corresponding increases in FM, VAT, and TM may be a result of coaches encouraging players to increase their total size without considering that the increase in size will result in changes in both LM and FM. Although there are no studies that specifically analyzed a player's age and body composition, there are previous studies that have examined year of college and body composition (1,12,23,26). Those studies reported significant increases in %BF and LM, in year 1 of player's collegiate year and years 2 and 3 of a player's career (1,12,23,26). This is consistent with the results of this study where we observed significant changes in LM, TM, and BMD from 18 to 19 and 20 years, and in the middle of player career jumping from age 18 to 20 years (VAT) or age 21 years (FM).

Overall, strengths of the current study include a large sample size, the use of DXA, the same technician performing the postscan analysis using one enCore software version, and the analysis of longitudinal body composition changes given defined seasons, ages, and position groups. Although the results of this study are novel, there are limitations including the use of different scanning locations and scanning technicians for the players, lack of seasonal activity, nutrition, and injury status documentation, and year of eligibility was not defined. However, the influence of these biases is limited by having a large sample size and Universities using best practices when scanning their players.

In conclusion, this study examined longitudinal changes in body composition by season, position, and player's age in NCAA Division I football players using DXA. Linemen had the highest %BF, FM, VAT, LM, TM, and BMD across each season and age. All position groups' body composition significantly worsened from the preseason to the postseason and improved from the preseason and postseason to the spring season. Finally, each position group saw an increase in FM (1.3 kg), VAT (0.17 kg), LM (2.7 kg), TM (4.2 kg), and BMD (0.1 $g \cdot cm^{-2}$) with each year of age.

Practical Applications

During the competitive season, it is not usual to observe a decrease in body mass, accompanied by a decrease in LM. In addition, although the absolute values for FM, LM, and VAT by position are different, relative changes by age and season are essentially the same. Therefore, coaches may expect similar body composition fluctuations to occur among position groups by age and season. Coaches may also expect that players will have large changes in body composition over their career, when in reality the changes that players will experience are relatively small. Finally, coaches often incorporate position-specific training regimens into field training and in the weight room, and therefore, it is important for athletes to obtain the appropriate body composition for their position to be successful on the field (1,21). This study aids in determining positional longitudinal body composition norms that can assist practitioners in targeting safe and realistic annual body composition changes.

From an overall health perspective, it is important to recognize that obesity has become a concern in football players (14,22,28). Studies have noted that football players have a high risk of developing cardiovascular disease risk factors despite the high intensity and volume of activity, which can provide negative long-term health risks for these individuals (2,27). Overall, coaches may consider focusing on building LM in players who need to gain weight and provide nutritional education to avoid unhealthy increases in FM.

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