PERFORMANCE AND BLOOD PRESSURE CHARACTERISTICS OF FIRST-YEAR NATIONAL COLLEGIATE ATHLETIC ASSOCIATION DIVISION I FOOTBALL PLAYERS

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ABSTRACT

Carbuhn, AF, Womack, JW, Green, JS, Morgan, K, Miller, GS, and Crouse, SF. Performance and blood pressure characteristics of first-year National Collegiate Athletic Association Division I football players. *J Strength Cond Res* 22: 1347–1354, 2008—The authors were aware of no published studies in which the performance characteristics of first-year National Collegiate Athletic Association Division I collegiate football players were reported. From 2003 to 2006, 73 freshman and 12 transfer football recruits were tested before twice-a-day practices for bench press (BP), squat (SQ), power clean (PC), vertical jump (VJ), calculated jump power (CP), treadmill endurance capacity ($\dot{V}O_2$peak), and maximal treadmill time (MTT). Individuals were grouped by player position for descriptive statistical analysis. As a group, offensive linemen (OL), defensive linemen (DL), linebackers (LB), tight ends (TE), and running backs (RB) averaged 152.8 kg for BP, 210.5 kg for SQ, 127.3 kg for PC, and 224.2 W for CP. These values were 22% to 30% higher than those for quarterbacks (QB), wide receivers (WR), defensive backs (DB), and kickers (K), who together averaged 120.2 kg for BP, 163.4 kg for SQ, 104.6 kg for PC, and 172.4 W for CP. Quarterbacks, WR, DB, and K as a group showed the highest MTT (13:13 $m \cdot s^{-1}$) and $\dot{V}O_2$peak values (47.24 $mL \cdot kg^{-1} \cdot min^{-1}$), 15% to 20% higher than those for OL, DL, LB, RB, and TE, who averaged 11:27 $m \cdot s^{-1}$ for MTT and 39.51 $mL \cdot kg^{-1} \cdot min^{-1}$ for $\dot{V}O_2$peak. Running backs, TE, LB, DB, and WR averaged 82.56 cm for VJ, which was 14% higher than that for DL, QB, K, and OL, who averaged 72.72 cm. On the basis of average resting blood pressure, 23.5% (20 players) were categorized as hypertensive (i.e., ≥140/90 mm Hg), 54% (46 players) as prehypertensive (i.e., 120–139/80–89 mm Hg), and 22.5% (19 players) as normal (i.e., <120/80 mm Hg). These data serve as a basis for comparisons among other Division I programs, benchmarking development and improvement through training, and creating position performance norms for incoming football athletes.

KEY WORDS speed, strength, endurance, power, freshman, hypertension

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INTRODUCTION

Off-season football training is quite different from that of most other popular sports of today. Sports such as basketball and baseball commit relatively more off-season practice time to sport-specific, skill development training compared to football, in which a player's development of strength, power, and speed are emphasized. Thus, the use of the 1 repetition maximum (1RM) strength testing and other assessments of strength and power (e.g., speed, agility, sprinting, and jumping) are critical measures related to game performance (1). These testing values are used by the strength and conditioning specialist to plan training protocols that will promote greater gains in strength, power, and speed. Due to modern, year-round training programs, better training methodologies, and changing game strategies calling for larger, more powerful athletes, the overall size, strength, power, and speed of present-day collegiate players tend to be greater when compared with collegiate players of previous decades (15).

The physiologic and morphologic profiles of a football athlete are important contributors to physical performance and success at any playing position. Furthermore, player health and risk of future disease may be affected by his present physical condition and presence of disease risk factors, such as hypertension and obesity. The authors have previously reported the position-by-position morphological characteristics of first-year collegiate football athletes and

Table 1. List of abbreviations of player positions used in the study.

Player positions	
Abbreviation	Definition
OL	Offensive lineman
TE	Tight end
DL	Defensive lineman
QB	Quarterback
LB	Linebacker
K	Kicker
WR	Wide receiver
DB	Defensive back
RB	Running back

compared them to professionals at the same playing position (9). Kaiser et al. (9) concluded that even though first-year football players were classified as overweight or obese according to body mass index (BMI) standards, their measured body fat percentages, which ranged from 9.6% to 22.3%, were within healthy limits for their age. Also, the trends in body morphology between the playing positions of first-year players paralleled their professional counterparts; for example, the defensive backs were the lightest and shortest, while the offensive linemen were the heaviest and tallest. Blood pressure characteristics of American football players have seldom been reported, so the health risk of these athletes that may be associated with hypertension is virtually unknown.

Although measures of muscular power, strength, physical agility, and speed, along with tests of endurance capacity, sprinting, and jumping are commonly used by strength and conditioning practitioners to evaluate football athletes, few comparative data have been published (3,6–8,14–16). Furthermore, data reported in the existing publications are from football players experienced in a collegiate or professional strength and conditioning program. The authors found only 6 publications of football performance data from National Collegiate Athletic Association (NCAA) Division I, II, or III or junior college players since 1990 (3,6–8,14,15) and only 1 since 1980 in which professional players were subjects (16). The authors have been unable to locate any published studies on performance or blood pressure characteristics of first-year collegiate football athletes prior to beginning an NCAA Division I strength and conditioning program. Thus, a need exists for more published data to describe by playing position the physical and performance attributes as well as the blood pressure characteristics of these athletes. For example, player position data related to performance characteristics, such as 1RM bench press (BP), back squat (SQ), and power clean (PC), vertical jump

Table 2. Performance values and *SD*s for first-year National Collegiate Athletic Association Division I football players.

	OL	TE	DL	QB	LB	K	WR	DB	RB
MTT (min)	11.1 ± 1*† ($n = 13$)	12.3 ± 0.6*‡ ($n = 3$)	10.7 ± 1.4† ($n = 11$)	13.4 ± 0.7‡ ($n = 5$)	11.5 ± 1*† ($n = 12$)	13.2 ± 0.6‡ ($n = 3$)	13.1 ± 0.9‡ ($n = 10$)	13.2 ± 1.4‡ ($n = 16$)	11.7 ± 1.5*† ($n = 8$)
$\dot{V}O_2$peak ($mL\cdot kg^{-1}\cdot min^{-1}$)	36.7 ± 5.3§ ($n = 12$)	40 ± 1.2*‡§ ($n = 3$)	38.3 ± 5.6†§ ($n = 11$)	44.6 ± 6.8*†‡ ($n = 5$)	41 ± 5.6*†§ ($n = 12$)	50.4 ± 4.5‡ ($n = 3$)	47.1 ± 4.8*‡ ($n = 10$)	46.9 ± 6.1*‡ ($n = 16$)	41.5 ± 7.7*†§ ($n = 8$)
1RM BP (kg)	154.9 ± 12.6‡ ($n = 12$)	148.5 ± 13.1*‡ ($n = 3$)	161.1 ± 11.4‡ ($n = 12$)	128.6 ± 14*†§ ($n = 5$)	147 ± 22.6*†‡ ($n = 11$)	103 ± 13.1‖ ($n = 3$)	123.2 ± 20.4§‖ ($n = 10$)	125.9 ± 16.7†§ ($n = 18$)	152.3 ± 31.9‡ ($n = 8$)
1RM SQ (kg)	229.9 ± 33.6‡ ($n = 12$)	205.3 ± 19.1*‡ ($n = 3$)	216.7 ± 13.2‡ ($n = 12$)	175.5 ± 26.2*†§ ($n = 5$)	200 ± 24*†‡ ($n = 10$)	140.9 ± 19.3‖ ($n = 2$)	164.5 ± 18.2§‖ ($n = 10$)	172.7 ± 23.9†§ ($n = 15$)	200.6 ± 21.5*†‡ ($n = 8$)
1RM PC (kg)	135.2 ± 11.6‡ ($n = 13$)	126.7 ± 7.6*‡ ($n = 3$)	131 ± 15.3‡ ($n = 12$)	110 ± 11.7* ($n = 5$)	125 ± 19*‡ ($n = 10$)	90 ± 7.1† ($n = 2$)	109.5 ± 10.7* ($n = 10$)	108.9 ± 13.2* ($n = 15$)	118.1 ± 12.9*‡ ($n = 8$)
VJ (cm)	69.2 ± 7† ($n = 12$)	86.8 ± 6‡ ($n = 3$)	75.4 ± 5.9*† ($n = 12$)	75.2 ± 5.8*† ($n = 5$)	79.6 ± 7.3*‡ ($n = 10$)	71.1 ± 4.4† ($n = 3$)	81.3 ± 3.3*‡ ($n = 10$)	84.2 ± 7‡ ($n = 18$)	80.9 ± 7.1*‡ ($n = 9$)
CP (W)	249 ± 17.2‡ ($n = 12$)	230.4 ± 7.8‡ ($n = 3$)	240.3 ± 23.3‡ ($n = 12$)	180 ± 13.4†§ ($n = 5$)	208.4 ± 17.2* ($n = 10$)	162.3 ± 22.9§ ($n = 3$)	173.4 ± 15.9†§ ($n = 10$)	173.95 ± 12.9†§ ($n = 18$)	194 ± 22.8*† ($n = 9$)

*†‡§‖Means with the same symbol(s) are not significantly different, $p = 0.05$.
OL = offensive lineman; TE = tight end; DL = defensive lineman; QB = quarterback; LB = linebacker; K = kicker; WR = wide receiver; DB = defensive back; RB = running back; MTT = maximal treadmill time; 1RM = 1 repetition maximum; BP = bench press; SQ = back squat; PC = power clean; VJ = vertical jump; CP = calculated power.

Table 3. Height, weight, resting and maximal heart rates, and blood pressure values with *SD*s for first-year National Collegiate Athletic Association Division I football players.

	OL	TE	DL	QB	LB	K	WR	DB	RB
Height (cm)	196.7 ± 3.7* (*n* = 13)	194.7 ± 5.3* (*n* = 3)	193 ± 3.6*† (*n* = 12)	190 ± 3.8†‡ (*n* = 5)	187.4 ± 4.4‡ (*n* = 12)	188 ± 5.1‡ (*n* = 3)	187.5 ± 3.7‡ (*n* = 10)	182 ± 2.9§ (*n* = 18)	181.5 ± 3§ (*n* = 9)
Weight (kg)	136.95 ± 9.4* (*n* = 13)	111.97 ± 2.5‡ (*n* = 3)	125.5 ± 12.4† (*n* = 12)	94 ± 5.8‖¶ (*n* = 5)	105.3 ± 6.5‡§ (*n* = 12)	86.95 ± 10.1¶ (*n* = 3)	87 ± 6.9¶ (*n* = 10)	85.9 ± 6.7¶ (*n* = 18)	97.98 ± 13.1§‖ (*n* = 9)
Resting HR (b·min⁻¹)	76 ± 12.5* (*n* = 13)	76 ± 9.5* (*n* = 3)	68 ± 6.4* (*n* = 12)	73 ± 8.5* (*n* = 5)	73 ± 7.9* (*n* = 12)	72 ± 5.6* (*n* = 3)	71 ± 7* (*n* = 10)	71 ± 11.5* (*n* = 18)	65 ± 10.2* (*n* = 9)
Resting SBP (mm Hg)	133 ± 14* (*n* = 13)	132 ± 2* (*n* = 3)	127 ± 12.9* (*n* = 12)	126 ± 7.6* (*n* = 5)	126 ± 8.3* (*n* = 12)	121 ± 1* (*n* = 3)	125 ± 9.2* (*n* = 10)	126 ± 6.8* (*n* = 18)	134 ± 14.5* (*n* = 9)
Resting DBP (mm Hg)	82 ± 7.2* (*n* = 13)	82 ± 6* (*n* = 3)	78 ± 8.4* (*n* = 12)	79 ± 5* (*n* = 5)	76 ± 9.9* (*n* = 12)	79 ± 2.3* (*n* = 3)	80 ± 8* (*n* = 10)	80 ± 7.8* (*n* = 18)	82 ± 9.3* (*n* = 9)
Maximal HR (b·min⁻¹)	191 ± 8.95* (*n* = 13)	193 ± 2.7* (*n* = 3)	185 ± 7.2* (*n* = 11)	189 ± 8.9* (*n* = 5)	187 ± 5.3* (*n* = 12)	191 ± 6* (*n* = 3)	193 ± 8.5* (*n* = 10)	195 ± 8.5* (*n* = 16)	195 ± 8.2* (*n* = 8)
Maximal SBP (mm Hg)	191 ± 23.2* (*n* = 13)	177 ± 32.2* (*n* = 3)	182 ± 14.4* (*n* = 11)	168 ± 21.6* (*n* = 5)	183 ± 29.9* (*n* = 12)	175 ± 5* (*n* = 3)	182 ± 28.4* (*n* = 10)	173 ± 19.3* (*n* = 16)	175 ± 20.9* (*n* = 8)
Maximal DBP (mm Hg)	79 ± 7.6* (*n* = 13)	83 ± 6.4* (*n* = 3)	83 ± 11.1* (*n* = 11)	82 ± 4.6* (*n* = 5)	81 ± 10.9* (*n* = 12)	78 ± 7.2* (*n* = 3)	75 ± 7.5* (*n* = 10)	82 ± 10.3* (*n* = 16)	80 ± 14.6* (*n* = 8)

*†‡§‖¶Means with the same symbol(s) are not significantly different, $p < 0.05$.
OL = offensive lineman; TE = tight end; DL = defensive lineman; QB = quarterback; LB = linebacker; K = kicker; WR = wide receiver; DB = defensive back; RB = running back; HR = heart rate; SBP = systolic blood pressure; DBP = diastolic blood pressure.

(VJ), endurance capacity ($\dot{V}O_2$peak), systolic blood pressure (SBP), and diastolic blood pressure (DBP), would be of great interest to sports medicine practitioners. Not only would such data be of value from a comparative and health perspective, but it would also serve to benchmark training and maturation performance changes throughout the athlete's collegiate career. Therefore, the purpose of this study was twofold: to establish a position-by-position performance and blood pressure profile of first-year players entering an NCAA Division I football program and, when available, to compare their profiles to those published for professional and other NCAA Division I, II, and III and junior college football athletes.

Methods

Experimental Approach to the Problem

To determine the performance and blood pressure characteristics of the first-year collegiate football player, first-year recruits to an NCAA Division I football program were required to complete a series of tests in the strength and conditioning facility and complete an endurance treadmill protocol in an exercise physiology laboratory. These data were grouped by the player's projected position and compared with published data on professional football players and starting players in NCAA Division I, II, and III schools and junior colleges.

Subjects

The sample was composed of true freshman ($n = 73$) and transfer scholarship ($n = 12$) football players; the transfer players were primarily from junior college football programs. The physiological and performance measurements were completed in early August of 2003 through 2006, just prior to the beginning of twice-a-day football practices. Listed in Table 1 are the abbreviations for player positions that were reported. Each first-year player signed a form of written consent prior to participation in the study. This study was approved by the Texas A&M University Institutional Review Board for Research with Human Subjects.

Procedures

The performance data were gathered by the strength and conditioning coaches and by trained exercise physiologists and staff at the Sydney and J.L. Huffines Institute for Sports Medicine and Human Performance on the campus of Texas A&M University. Muscle performance data included measures of 1RM BP, SQ, PC, VJ, and calculated power (CP) using the Lewis formula (10). The endurance capacity test included measures of resting heart rate (HR), SBP, DBP, exercise-derived $\dot{V}O_2$peak, maximal treadmill time (MTT) in minutes, maximal HR, maximal SBP, and maximal DBP. The recording of a 1RM lift involved the subject being able to lower and lift a weight unaided. The proper techniques for BP, SQ, PC, and VJ have been previously published (2).

TABLE 4. Performance values and *SD*s of first-year National Collegiate Athletic Association Division I football players versus National Football League, Division I, Division II, Division III, and junior college players, by position.

Division	Age (y)	Height (cm)	Weight (kg)	1RM BP (kg)	1RM SQ (kg)	1RM PC (kg)	VJ (cm)	CP (W)
OL								
First-year	18.8 ± 2	196.7 ± 3.7	136.95 ± 9.4	154.9 ± 12.6	229.9 ± 33.6	135.2 ± 11.6	69.2 ± 7.1	249 ± 17.2
NFL	24.1 ± 2.8	193.3 ± 3.9	117.7 ± 8.8	160.9± 20.9				
Division I		191.3 ± 1.9	133.2 ± 8.1	174 ± 27.6	251.3 ± 33.8	143.4 ± 16	68.8 ± 6.2	244.2 ± 16.9
Division II		189 ± 2	128.4 ± 11.9	160 ± 25	221.6 ± 35.8	132 ± 17.4	60.4 ± 8.6	220.6 ± 23.3
Division III				138.7	177.3	118	62.5	
Junior college		189.7 ± 5.2	121.6 ± 12.5	147.6 ± 23.1	201.4 ± 28.8		56.3 ± 8.2	
TE								
First-year	18	194.7 ± 5.3	112 ± 2.5	148.5 ± 13.1	205.3 ± 19.1	126.7 ± 7.6	86.8 ± 6	230.4 ± 7.8
NFL	24.2 ± 2	190.5 ± 4.34	104.5 ± 6.2	154.6 ± 25.3				
Division I		190.3 ± 1.1	113.7 ± 6.4	172.4 ± 16.5	232.4 ± 37.3	140.9 ± 14.3	79.6 ± 7.2	224.4 ± 15.3
Division II		190 ± 1.9	104.5 ± 8.8	144.3 ± 16.2	202.5 ± 29	122.6 ± 18.7	70.1 ± 8.7	194 ± 18.6
Division III				150.3	165.4	116.5	74.2	
Junior college		190 ± 3.7	101.3 ± 5.3	136.6 ± 17	179.7 ± 20.6		68 ± 7.2	
DL								
First-year	18.2 ± 0.6	193 ± 3.6	125.5 ± 12.4	161.2 ± 11.4	216.7 ± 13.2	131.5 ± 15.3	75.4 ± 5.9	240.3 ± 23.3
NFL	24.1 ± 2.8	193.3 ± 3.9	117.7 ± 8.8	160.9± 20.9				
Division I		188 ± 2.7	120.7 ± 8.8	180.1 ± 24	246.5 ± 34.8	146.8 ± 17.4	77.9 ± 8.2	234.8 ± 18.1
Division II		187.3 ± 1.8	116.9 ± 11.6	161.7 ± 20.7	219.3 ± 36.4	132.7 ± 22	66.9 ± 11.3	210.4 ± 23.6
Division III				134.2	163.2	127.4	70.5	
Junior college		187.9 ± 5.2	112.8 ± 10.8	148.5 ± 22	199.4 ± 38.1		62 ± 10.7	
QB								
Division								
First-year	18 ± 0.7	190 ± 3.8	94 ± 5.8	128.6 ± 14	175.5 ± 26.2	110 ± 11.7	75.2 ± 5.8	180 ± 13.4
NFL	24 ± 2.4	184.7 ± 4.01	94.1 ± 8.1	133.2 ± 18.2				
Division I		185.8 ± 2	92.7 ± 6.3	162.9 ± 21.7	200.2 ± 45	124.6 ± 18.7	80.7 ± 6.4	184 ± 15.4
Division II		186.1 ± 1.9	93.4 ± 7.9	128.9 ± 23.3	179 ± 40.3	120 ± 19.2	70.3 ± 9.3	174.9 ± 16.4
Division III				121.6	189.5	103.9	67.1	
Junior college		185.7 ± 6.2	85.8 ± 7	113.4 ± 20.9	155.8 ± 33.7		68.6 ± 10.1	
LB								
First-year	20 ± 2.5	187.4 ± 4.4	105.3 ± 6.5	146.9 ± 22.6	200 ± 24	125 ± 19	79.6 ± 7.31	208.4 ± 17.2
NFL	24.2 ± 2	190.5 ± 4.3	117.7 ± 8.8	154.5 ± 25.3				
Division I		185.1 ± 1.4	103.8 ± 5.2	159.5 ± 23.7	240.5 ± 36.5	144.3 ± 16.4	83.2 ± 7.8	209 ± 13.8
Division II		184.2 ± 1.7	104 ± 29.4	146.2 ± 21.7	209 ± 37.7	131.6 ± 22.8	72.4 ± 10.8	188.5 ± 16.4
Division III				163.3	156.6	121.9	71.5	
Junior college		185.8 ± 3.8	99 ± 5.8	142 ± 23.5	184.7 ± 35.4		68.8 ± 8	
K								
First-year	18 ± 1	188 ± 5.1	86.95 ± 10.1	103 ± 13.1	140.9 ± 19.3	90 ± 7.1	71.1 ± 4.4	162.3 ± 22.9
NFL	24 ± 2.4	184.7 ± 4	94.1 ± 8.1	133.2 ± 18.2				
Divisions I–III and junior college								
WR								
First-year	18.4 ± 0.7	187.5 ± 3.7	87 ± 6.9	123.2 ± 20.4	164.5 ± 18.2	109.5 ± 10.7	81.3 ± 3.3	173.4 ± 15.9
NFL	24.6 ± 2.8	181.9 ± 4.8	85 ± 7.1	124.5 ± 26				
Division I		183 ± 2.3	85.6 ± 7	151.2 ± 26.5	205.6 ± 40.4	127.5 ± 15.2	87.4 ± 7	177 ± 17.9
Division II		184 ± 2.3	83.4 ± 5.5	122.6 ± 20.4	173.8 ± 35.3	123.7 ± 16.9	77.8 ± 12.1	162.4 ± 17.1
Division III				150.3	165.4	116.5	74.2	
Junior college		180.8 ± 5.7	80.3 ± 6.1	110.7 ± 17	160.6 ± 24		72.6 ± 9.9	

DB								
First-year	18.5 ± 1.2	182 ± 2.9	85.9 ± 6.7	125.9 ± 16.7	172.7 ± 23.9	108.9 ± 13.2	84.2 ± 6.98	173.95 ± 12.9
NFL	24.6 ± 2.8	181.9 ± 4.8	85 ± 7.1	124.5 ± 26				
Division I		180.1 ± 1.9	85.1 ± 5.8	142.4 ± 16.6	207.8 ± 39.6	127.1 ± 19.6	87.8 ± 7.8	175.9 ± 14.2
Division II		180.3 ± 1.7	83.2 ± 6.4	126 ± 18.2	176.6 ± 37.9	116.1 ± 19.4	78 ± 10.3	163.4 ± 18.9
Division III				139.5	166	123.7	77.5	
Junior college		181.4 ± 5.3	83.8 ± 6.5	124.6 ± 18.9	165.6 ± 29.9		74.4 ± 7.8	
RB								
First-year	18.2 ± 0.4	181.5 ± 3	97.9 ± 13.1	152.3 ± 31.9	200.6 ± 21.5	118.1 ± 12.9	80.9 ± 7.1	194 ± 22.8
NFL	24 ± 2.37	184.7 ± 4	94.1 ± 8.1	133.2 ± 18.2				
Division I		181.3 ± 1.5	97.3 ± 8.9	174.9 ± 23.7	233.3 ± 32.6	138.3 ± 14.9	85.9 ± 7.7	199.1 ± 18.9
Division II		178.2 ± 2.0	95.4 ± 9.3	146.9 ± 19.7	214.8 ± 40.1	127.3 ± 21.9	74.2 ± 11	181.8 ± 16
Division III				121.6	189.5	103.9	67.1	
Junior college		178.2 ± 5.5	88.8 ± 7.9	135.1 ± 24.1	191.3 ± 32.2		72.2 ± 7.5	

OL = offensive lineman; 1RM = 1 repetition maximum; BP = bench press; SQ = back squat; PC = power clean; VJ = vertical jump; CP = calculated power; NFL = National Football League; TE = tight end; DL = defensive lineman; QB = quarterback; LB = linebacker; K = kicker; WR = wide receiver; DB = defensive back; RB = running back.

$\dot{V}O_2$peak was determined for each first-year football player by indirect, open-circuit calorimetry (CPX/D; Medical Graphics, St. Paul, MN) until volitional exhaustion on a treadmill by using the protocol developed by Bruce et al. (4). The highest recorded $\dot{V}O_2$ averaged over 30 seconds was considered the $\dot{V}O_2$peak for each subject, provided 2 of the following criteria were satisfied: leveling off of $\dot{V}O_2$ with further increases in workload; achievement of age-predicted maximal HR within 10 b·min^{-1}; or respiratory exchange ratio of at least 1.15. Maximal treadmill time was simply the exercise time in minutes and seconds to exhaustion. Heart rates at rest and throughout the exercise test were obtained from a 12-lead electrocardiogram, and blood pressures were obtained by sphygmomanometry.

Statistical Analyses

Tests for significance of player position mean differences were performed via analysis of variance (ANOVA) with Duncan multiple-range follow-up tests using SAS version 9.1 (SAS Institute, Inc., Cary, NC) statistical analysis software. Pearson product correlations were performed with SPSS for Windows version 12.0 (SPSS, Inc., Chicago, IL) to determine if any relationship existed between resting SBP and DBP and exercise-derived $\dot{V}O_2$peak, MTT, BP, SQ, PC, VJ, and CP. Descriptive statistics were performed to obtain means, *SD*s, and value ranges. Significance was established at $p \leq 0.05$.

Results

Average results grouped by playing positions for all measured variables are shown in Table 2. Not unexpectedly, the players projected as quarterbacks (QB), wide receivers (WR), defensive backs (DB), and kickers (K) posted the higher endurance capacity times and $\dot{V}O_2$peak values. Those projected to play offensive linemen (OL), defensive linemen (DL), linebackers (LB), tight ends (TE), and running backs (RB) were stronger and more powerful and outperformed the athletes at the other positions in BP, SQ, PC, and CP. The VJ incorporates some coordination skill in addition to power and was found to be highest in TE, DB, WR, RB, and LB. Height, weight, resting and maximal HR, and blood pressure values are presented in Table 3. Resting SBP was significantly and positively correlated (0.270) with body mass; that is, players with greater body masses exhibited relatively higher resting SBP. Resting SBP was also significantly and inversely correlated with exercise-derived $\dot{V}O_2$peak (−0.371) and MTT (−0.320); that is, players with lower MTT and exercise-derived $\dot{V}O_2$peak values exhibited relatively higher resting SBP. Resting DBP did not correlate with any of the measured variables. Most remarkable were the relatively elevated resting SBPs, which ranged from 121 mm Hg in K to 134 mm Hg in OL. Resting DBPs were slightly elevated as well.

TABLE 5. Endurance capacity values and *SD*s for first-year National Collegiate Athletic Association Division I football players versus NFL players.

Division/position	Age (y)	Height (cm)	Weight (kg)	$\dot{V}o_2$peak ($mL \cdot kg^{-1} \cdot min^{-1}$)	MTT (min)	Maximal heart rate ($b \cdot min^{-1}$)
FY/OL	18.8 ± 1.96	196.7 ± 3.67	136.95 ± 9.41	36.73 ± 5.26	11.11 ± 1.03	191 ± 8.95
NFL*/OL	24.1 ± 2.77	193.3 ± 3.94	117.73 ± 8.84	43 ± 5.5	12.7 ± 1.49	188 ± 8.85
FY/TE	18	194.7 ± 5.3	112 ± 2.49	40.1 ± 1.21	12.28 ± 0.63	193 ± 2.65
NFL/TE	24.2 ± 1.99	190.5 ± 4.34	104.5 ± 6.19	46.7 ± 5.32	13.6 ± 1.99	190 ± 7.88
FY/DL	18.2 ± 0.58	193 ± 3.6	125.5 ± 12.37	38.3 ± 5.6	10.74 ± 1.36	185 ± 7.2
NFL/DL	24.1 ± 2.77	193.3 ± 3.94	117.73 ± 8.84	43 ± 5.5	12.7 ± 1.49	188 ± 8.85
FY/QB	18 ± 0.71	190 ± 3.77	94 ± 5.8	44.62 ± 6.78	13.4 ± 0.65	189 ± 8.93
NFL/QB	24 ± 2.37	159.94 ± 3.48	94.1 ± 8.1	47.2 ± 5.02	13.7 ± 1.69	188 ± 14.88
FY/LB	20 ± 2.49	187.43 ± 4.38	105.27 ± 6.45	41 ± 5.55	11.46 ± 1.04	187 ± 5.32
NFL/LB	24.2 ± 1.99	190.5 ± 4.34	117.73 ± 8.84	46.7 ± 5.32	13.6 ± 1.99	190 ± 7.88
FY/K	18 ± 1	188 ± 5.08	86.95 ± 10.08	50.4 ± 4.5	13.2 ± 0.59	191 ± 6
NFL/K	24 ± 2.37	184.7 ± 4.01	94.1 ± 8.1	47.2 ± 5.02	13.7 ± 1.69	188 ± 14.88
FY/WR	18.4 ± 0.7	187.45 ± 3.7	87 ± 6.9	47.1 ± 4.83	13.14 ± 0.93	193 ± 8.48
NFL/WR	24.6 ± 2.78	181.86 ± 4.8	85 ± 7.06	50.1 ± 4.52	14.2 ± 1.22	190 ± 7.69
FY/DB	18.5 ± 1.15	182.03 ± 2.89	85.92 ± 6.68	46.9 ± 6.13	13.2 ± 1.43	195 ± 8.5
NFL/DB	24.6 ± 2.78	181.86 ± 4.8	85 ± 7.06	50.1 ± 4.52	14.2 ± 1.22	190 ± 7.69
FY/RB	18.22 ± 0.44	181.5 ± 3.04	97.98 ± 13.1	41.5 ± 7.7	11.7 ± 1.5	195 ± 8.83
NFL/RB	24 ± 2.37	184.7 ± 4.01	94.1 ± 8.1	47.2 ± 5.02	13.7 ± 1.69	188 ± 14.88

* NFL player data from Shields et al. (16).
MTT = maximal treadmill time; FY = first-year; OL = offensive lineman; NFL = National Football League; TE = tight end; DL = defensive lineman; QB = quarterback; LB = linebacker; K = kicker; WR = wide receiver; DB = defensive back; RB = running back.

DISCUSSION

As presented in Table 2, the physical performance of the athletes varied with their projected playing position. The QB, WR, DB, and K players achieved significantly higher endurance capacity times (i.e., MTT) and $\dot{V}o_2$peak values expressed relative to body mass. This could be partly due to their lower recorded body mass, body fat percentage, and BMI (9). Also, the game-type nature and, hence, conditioning of players in these positions involve fewer bouts of intense opposing collision forces, with a tendency to rely more on speed and overall aerobic endurance during competition and practice. Similar results for endurance capacity of players by position was also reported by Shields et al. (16) in professional football athletes; the only difference from the current findings was that professional RB endurance capacities were grouped with QB and K.

As may be expected based on the way the modern game of football is played, OL, DL, LB, TE, and RB in the current study were, on average, comparatively stronger and more powerful athletes. Their greater ability to produce muscular force and power is, in part, related to their body morphology. The authors have previously reported that the body masses and BMI measures of this group are the highest of the football athletes (9). Also, due to the high explosive power and ability requirements of their playing positions to defend violent opposing forces, heavily muscled and powerful athletes tend to be selected for and are most successful at these positions. Depending on the offensive scheme of any specific football team, the TE may function much like an OL, or alternatively, he may be utilized more like a WR. The data seem to reflect this dual role. The TE athletes exhibited $\dot{V}o_2$peak values slightly, but not significantly, lower than those for QB, WR, and DB players, yet the TE players were also among the strongest and most powerful. The findings related to player position characteristics generally agree with those published by others in older, more experienced football athletes (6–8).

Grouping on VJ performance placed RB, TE, WR, DB, and LB together with the most similar VJ scores. The VJ requires both coordination and explosive power, a combination that, together with lower body mass, is typically associated with players at these positions. The current results corroborate those previously published for Division I, II, and III football athletes (7,8).

Football teams use an array of offensive and defensive schemes, but the fundamental nature of required athletic ability for success in each playing position appears to remain consistent. Support for this conjecture is given by results of previous studies in which position-specific performance characteristics were similar to those in the current study. This suggests that current testing methods can help profile football athletes for their optimal playing position.

No significant differences were found among the players at different positions in resting and exercise HR, SBP, and DBP

(Table 3). In a review of the related literature, only Shields et al. (16) reported professional players' maximal exercise HR and found no significant difference among player positions. With little comparative data published for blood pressures of collegiate football athletes, the current study compared first-year players' resting blood pressures, a known risk factor for cardiovascular disease, to recommended levels set by the American Heart Association (13). According to these standards, 23.5% ($n = 20$) of the players were categorized as hypertensive (i.e., ≥140/90 mm Hg), 54% ($n = 46$) as prehypertensive (i.e., 120–139/80–89 mm Hg), and only 22.5% ($n = 19$) as normal (i.e., <120/80 mm Hg). By comparison, 11.2% of the general population aged 20 to 34 years is reportedly hypertensive (13). Sixty-nine percent of the subject sample was composed of black players, with 27% white and 4% other, yet resting blood pressure values were not influenced by ethnicity. However, the blood pressure averages of the first-year black (i.e., 127/79 mm Hg) and white (i.e., 129/79 mm Hg) football athletes were higher than the average values for the general population of black (i.e., 118/64 mm Hg) and white (i.e., 117/66 mm Hg) adolescents 17 years of age (12). The current blood pressure average values were similar to those reported by Millard-Stafford and Sparling (11) for black and white Division I-A football athletes (i.e., 128/78 mm Hg and 129/77 mm Hg, respectively). Reasons for the high prevalence of elevated blood pressure in these football athletes are presently not known. It seems unlikely that their practice of high-intensity resistance training is a primary cause, since others have demonstrated that blood pressure was maintained or decreased with chronic resistance training (5). Whether the elevated blood pressures found in football athletes have negative health effects or are simply the reversible consequences of the specific training practices of these specialized athletes is not known. Analogous to heart enlargement as an adaptive response to physical training, it may be that increased blood pressure is a characteristic of successful football athletes and not a risk marker for disease. Interestingly, resting SBP was positively correlated with body mass and inversely correlated with MTT and $\dot{V}O_2$peak values. Thus, those players with the highest aerobic capacity also exhibited lower resting SBPs. This finding leads naturally to the speculation that blood pressure may be reduced in these athletes by aerobic conditioning and weight loss. To the authors' knowledge, this hypothesis has not been tested in an experimental study.

The scarcity of recently published physical performance information became readily apparent when the performance data of first-year Division I football players was attempted to be compared to other published findings (Table 4). In fact, no published comparative data could be found for first-year football players. Published performance characteristics from Divisions I, II, and III and junior college football athletes were measured on players with a history of training in a collegiate strength and conditioning program (7,8). By comparison with published data for older, experienced Division I football players, the first-year players in this study exhibited lower BP (–14%), SQ (–14%), PC (–12%), and VJ (–3%) values (8). This suggests that training in a Division I collegiate program is effective in increasing all measures of muscular strength and power in football athletes. Compared to Division II players, the first-year players in this study exhibited lower SQ and PC values (–2.2% and –4.5%, respectively), nearly equivalent BP values, and higher VJ and CP (+9.4% for both) (8). The first-year players demonstrated higher BP, SQ, PC, and VJ (+3%, +14.5%, +4%, and +12%, respectively) compared to published data for Division III players (14). Finally, in comparison to junior college players, the first-year players' average BP was +8% higher; their average SQ was +9% higher; and their average VJ was +17% higher (6). By merely observing these percentage differences, the first-year players' performance characteristics for BP, SQ, and PC were most similar to those for Division II athletes, while their characteristics for VJ and CP were most similar to those for Division I athletes. Division III and junior college players had values well below the first-year players' values. These data likely reflect the recruiting practices of NCAA Division I universities and their ability to recruit athletes who are physically more advanced compared to those recruited to universities of lower NCAA divisions.

To the authors' knowledge, since 1980, only Shields et al. (16) have published related performance data on professional football athletes. The primary performance data reported in their publication was BP, with no additional power, agility, or speed data. Bench press values compared to professionals were lower for the first-year OL in this study by –4%, for TE by –4%, for QB by –3.5%, and for K by –23%. Collegiate WR, DL, and DB values were similar to those of the professionals, and the BP average for the current study's collegiate RB group was about 14% higher than that reported for professional football athletes. In terms of endurance capacity measures, mean treadmill time and $\dot{V}O_2$peak were lower in the first-year players than in the professionals (Table 5).

Practical Applications

In summary, to the authors' knowledge, this is the first study to quantify physical performance and blood pressure characteristics of first-year football athletes at a Division I Football Bowl Subdivision university. For the practitioner, these data will serve as a position-specific standard for comparison. These data also can serve as a benchmark to compare performance changes that accompany training throughout a player's collegiate career. This would allow trainers and coaches to quantify the developmental improvement of performance for players at each playing position, which in turn would provide a rationale for better positional strength and conditioning training programs to optimize athletic performance. Also, it is suggested that these data can be useful to sports medicine practitioners in assessing appropriate blood pressure values in football athletes. Finally, over 75% of the first-year football players in this study were categorized as prehypertensive or hypertensive. Whether this is a benign physical adaptation to participation in this sport or confers upon the athlete an increased risk of cardiovascular disease and potential declines in athletic performance remains to be determined.

References

1. Allerheiligen, B and Arce, HH. Coaches' roundtable: testing for football. *Natl Strength Cond Assoc J* 5: 12–19, 1983.
2. Baechle, TR and Earle, RW. *Essentials of Strength Training and Conditioning*. Champaign, IL: Human Kinetics, 2000.
3. Black, W and Roundy, E. Comparisons of size, strength, speed, and power in NCAA Division 1-A football players. *J Strength Cond Res* 8: 80–85, 1994.
4. Bruce, RA, Kusumi, F and Hosmer, D. Maximal oxygen intake and homographic assessment of functional aerobic impairment in cardiovascular disease. *Am Heart J* 85: 546–562, 1973.
5. Carter, JR, Ray, CA, Downs, EM, and Cooke, WH. Strength training reduces arterial blood pressure but not sympathetic neural activity in young normotensive subjects. *J Appl Physiol* 94: 2212–2216, 2003.
6. Dos Remedios, R and Holland, G. Physical and performance characteristics of community college football players. *Natl Strength Cond Assoc J* 14: 9–12, 1992.
7. Fry, AC and Kraemer, WJ. Physical performance characteristics of American collegiate football players. *J Appl Sport Sci Res* 5: 126–138, 1991.
8. Garstecki, MA, Latin, RW, and Cuppett, MM. Comparison of selected physical fitness and performance variables between NCAA Division I and II football players. *J Strength Cond Res* 18: 292–297, 2004.
9. Kaiser, GE, Womack, JW, Green, JS, Pollard, B, Miller, GS, and Crouse, SF. Morphological profiles for first-year NCAA Division I football players. *J Strength Cond Res* 22: 243–249, 2008.
10. Matthews, D and Fox, E. *The Physiological Basis of Physical Education and Athletics* (2nd ed.). Philadelphia: W.B. Saunders, 1979.
11. Millard-Stafford, M and Sparling, PB. Comparison of blood pressure and blood lipids in black and white collegiate male athletes. *Am J Hum Biol* 4: 265–270, 1992.
12. Muntner, P, He, J, Cutler, JA, Wildman, RP, and Whelton, PK. Trends in blood pressure among children and adolescents. *JAMA* 291: 2107–2113, 2004.
13. Rosamond, W, Flegal, K, Friday, G, Furie, K, Go, A, Greenlund, K, Haase, N, Ho, M, Howard, V, Kissela, B, Kittner, S, Lloyd-Jones, D, McDermott, M, Meigs, J, Moy, C, Nichol, G, O'Donnell, CJ, Roger, V, Rumsfeld, J, Sorlie, P, Steinberger, J, Thom, T, Wasserthiel-Smoller, S, and Hong, YL. Heart disease and stroke statistics–2007 update: a report from the American Heart Association Statistics Committee and Stroke Statistics Subcommittee. *Circulation* 115: E69–E171, 2007.
14. Schmidt, DW. Strength and physiological characteristics of NCAA Division III American football players. *J Strength Cond Res* 13: 210–213, 1999.
15. Secora, CA, Latin, RW, Berg, KE, and Noble, JM. Comparison of physical and performance characteristics of NCAA Division I football players: 1987 and 2000. *J Strength Cond Res* 18: 286–291, 2004.
16. Shields, CL, Whitney, FE, and Zomar, VD. Exercise performance of professional football players. *Am J Sports Med* 12: 455–459, 1984.