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1 **QUANTIFICATION OF COMEPTITIVE GAME DEMANDS OF**
2 **NCAA DIVISION I COLLEGE FOOTBALL PLAYERS USING**
3 **GLOBAL POSITIONING SYSTEMS**

4
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8
9
10 **ABSTRACT**

11
12 The aim of the present study was to examine the competitive physiological movement
13 demands of NCAA Division I college football players using portable global positioning
14 system (GPS) technology during games, and to examine positional groups within
15 offensive and defensive teams, to determine if a player's physiological requirements
16 during games are influenced by playing position. Thirty-three National Collegiate
17 Athletic Association (NCAA) Division I Football Bowl Subdivision football players were
18 monitored using GPS receivers with integrated accelerometers (GPSports, Canberra,
19 Australia) during 12 regular season games throughout the 2014 season. Individual
20 datasets (n = 295) from players were divided into offensive and defensive teams, and

21 subsequent position groups. Movement profile characteristics including total, low-,
22 moderate-, high-intensity and sprint running distances (m), sprint counts, and
23 acceleration and deceleration efforts, were assessed during games. A one-way
24 ANOVA and post-hoc Bonferroni statistical analysis were used to determine differences
25 in movement profiles between each position group within offensive and defensive
26 teams. For both offensive and defensive teams, significant ($p < 0.05$) differences exist
27 between positional groups for game physical performance requirements. The results of
28 the present study identified that wide receivers (WR) and defensive backs (DB)
29 completed significantly ($p < 0.05$) greater total distance, high-intensity running, sprint
30 distance, and high-intensity acceleration and deceleration efforts compared to their
31 respective offensive and defensive positional groups. Data from the present study
32 provide novel quantification of position specific physical demands of college football
33 games and support the use of position-specific training in the preparation of NCAA
34 Division I college football players for competition.

35

36 Key Words: GPS, monitoring, American football

37

38 **INTRODUCTION**

39

40 American football is a field-based team sport requiring high levels of muscular strength,
41 power, speed and agility, and is characterized by intense collisions and repeated high-
42 intensity movements (27). American football games are intermittent in nature involving
43 short-duration high-intensity bouts of exercise which incorporate movements such as

44 sprinting, backpedaling, accelerating, decelerating, and physical collisions, separated by
45 transient periods of low-intensity recovery between plays (12). During the in-season
46 period of competition, players competing in NCAA Division I college football are
47 required to participate in twelve regular season games on a consecutive weekly basis.
48 Few studies have investigated (12,26) the demands of NCAA Division I football games
49 and as such, the movement characteristics of competition in college football players
50 remain ambiguous. While research (12,26) has provided a rudimentary description of
51 exercise to rest ratios encountered during NCAA Division I college football games, a
52 more detailed assessment of position-specific movement demands during competition
53 provides novel insight to improve our understanding of the demands of competition and
54 enable increased scope for position-specific training and conditioning programs to
55 optimize on-field performance.

56
57 The development of global positioning system (GPS) technology with integrated tri-axial
58 accelerometers have allowed the physiological demands of training and competition in
59 contact team sport to be quantified by tracking the movement of players (2,10,32).
60 Improvements in GPS technology have subsequently resulted in enhancements in
61 accuracy (13), and the validity and reliability of GPS to determine the movement
62 demands of team sports is well established (6,14,15,30). The quantification of team-
63 sport competition demands using GPS technology has been reported in sports similar in
64 nature to American football, including rugby league (2,10,24), rugby sevens (11),
65 Australian football league (AFL) (18,29,31), and rugby union (7,21). Further
66 substantiating the use of GPS technology to accurately determine position-specific

67 demands of team sport, Boyd et. al. (4) demonstrated the capacity of GPS units with
68 integrated accelerometry to differentiate between training drills and competitive games,
69 and discriminate between players competing in elite and sub-elite team-sport
70 competitions. Although GPS technology is widely used in team sports for analysis of
71 game and training movement demands, current literature on the movement profile
72 characteristics of American football players is limited (8).

73

74 DeMartini et. al. (8) reported movement profile characteristics associated with pre-
75 season training sessions in NCAA Division I college football by examining the physical
76 demands of Division I college football players during nine pre-season practices over the
77 course of eight days, utilizing GPS to evaluate total distance covered and running
78 velocity characteristics. The main findings reported by DeMartini et. al. (8) were that
79 non-linemen covered greater total distance and sprint distance than linemen, who
80 covered greater distance at slower speeds. To date, ambiguity remains regarding the
81 demands of in-season NCAA Division I college football games and team training
82 activities (8).

83

84 In American football each position group has distinct physiologic and biomechanical
85 demands associated with specific technical and tactical requirements (16), however
86 uncertainty exists regarding the position-specific movement demands of NCAA football
87 competition. Given the widespread inclusion of GPS technology in collegiate American
88 football programs, a detailed assessment of competitive movement profile

89 characteristics will provide sports performance specialists with quantified information on
90 game demands. A more comprehensive understanding of the demands of NCAA
91 football competition will augment our understanding of the position-specific movement
92 demands of NCAA college football players, and allow sport coaches to individualize
93 training programs that replicate the demands of American football games.

94

95 The aim of the present study was to 1) examine the competitive physiological
96 movement demands of NCAA Division I college football players using portable global
97 positioning system (GPS) technology during games, and 2) to examine positional
98 groups within offensive and defensive teams, to determine if a player's physiological
99 requirements during games are influenced by playing position. We hypothesized that
100 there will be substantial positional differences in movement demands of NCAA Division I
101 college football players during games. Data obtained will provide scope for
102 performance coaches seeking to optimize position-specific training regimens.

103

104 **METHODS**

105

106 **EXPERIMENTAL APPROACH TO THE PROBLEM**

107

108 Portable GPS and integrated tri-axial accelerometry technology was used in the present
109 study to quantify the position-specific movement characteristics of NCAA Division I

110 college football games. The GPS movement profile data was collected during twelve
111 regular season NCAA Division I college football games. All games were 60-minutes in
112 duration, comprised of four 15-minute quarters, each followed by a brief recovery
113 period, and played outdoors between the hours of 12:00 and 21:00 over a period of
114 twelve to thirteen weeks from September to November. All participants were required to
115 participate in a minimum of 75% of the total offensive or defensive plays for the GPS
116 datasets to be included in the present study. Each individual GPS dataset was
117 characterized as constituting either offensive or defensive team performance, and
118 subsequently divided into specific positional groups for the offense that included wide
119 receivers (WR), quarterbacks (QB), running backs (RB), tight ends (TE), offensive
120 linemen (OL), and for the defense that included defensive backs (DB), linebackers (LB),
121 defensive ends (DE) and defensive tackles (DL).

122

123 **SUBJECTS**

124

125 Thirty-three National Collegiate Athletic Association (NCAA) Division I Football Bowl
126 Subdivision (FBS) football players (age 20.7 ± 1.0 years; height 188.6 ± 7.2 cm; and
127 mass 106.7 ± 19.6 kg) participated in the present study. The heights and weights for
128 each position group are expressed as means \pm standard deviation and presented in
129 Table 1. All subjects were collegiate athletes whom had been selected to participate in
130 the football program eight months prior to the commencement of the study. All
131 participants in the present study took part in the teams' off-season physical

132 development training program that included a full-body strength and power training
133 program and specific skills and conditioning sessions designed to simulate the demands
134 of NCAA Division I college football competition. The present study comprises statistical
135 analysis of data collected as part of the day to day student athlete monitoring and
136 testing procedures within the university's football program. Researchers were provided
137 with de-identified GPS datasets from twelve regular season games for analysis. De-
138 identified data included participant playing position for the purposes of position-specific
139 data analysis. Ethical approval was obtained from the the university's human research
140 ethics committee.

141

142 ***Insert Table 1 Here***

143

144 **PROCEDURES**

145

146 *Global Positioning System Units.* The present study used commercially available GPS
147 receivers (SPI HPU, GPSports, Canberra, Australia) which operated in a non-differential
148 mode at a sampling frequency of 15 Hz. The GPS receivers also contain integrated tri-
149 axial accelerometers (IA), which operated at 100 Hz and assessed the frequency and
150 magnitude of full-body acceleration ($m \cdot \text{second}^{-2}$) in three dimensions, namely, anterior-
151 posterior, mediolateral, and vertical (17,22). Subjects had previously worn GPS
152 receivers in outdoor training sessions that included football-specific running, and skill-
153 related and game-simulated contact activities during a three week pre-season training

154 period. Prior to the commencement of each game, GPS receivers were placed outside
155 for 15 minutes to acquire a satellite signal, after which, receivers were placed in a
156 custom designed pocket attached to the shoulder pads of the subjects. Shoulder pads
157 were custom-fit for each individual, thereby minimizing movement of the pads during
158 competition. The GPS receivers used in the present study (66 g; 74 mm x 42 mm x 16
159 mm) were positioned in the center of the upper back, slightly superior to the scapulae.
160 Subjects were outfitted with the same GPS receiver for each of the twelve games.
161 Following the completion of games, GPS receivers were removed from the shoulder
162 pads, and subsequently downloaded to a computer for analysis utilizing commercially
163 available software (Team AMS, GPSports, Canberra, Australia). The validity and
164 reliability of GPS to measure distance and velocity during high-intensity exercise that
165 characterizes contact and noncontact team sports have been reported (3,9,14,25).
166 Johnston et. al. (14) have demonstrated GPS receivers utilized in the present study to
167 be valid for measuring total distance and average peak speed in a team sport simulation
168 circuit, with intraclass correlation values of interunit reliability reported to be 0.94 for
169 high speed running (14.00 – 19.99 km·h⁻¹) distance, 0.81 for very high speed running (>
170 20.00 km·h⁻¹) distance, - 0.20 for total distance, and – 0.14 for peak speed.

171

172 Data provided from GPS receivers were assessed as movement profile variables
173 including total, low-intensity, moderate-intensity, high-intensity and sprint distances (m),
174 max velocity achieved (km/h), and counts of sprint, acceleration and deceleration
175 efforts. Classifications of parameters of movement profile variables are described
176 below and presented in Table 2. Each of the GPS variables measured in the present

177 study was calculated using commercially available software (Team AMS, GPSports,
178 Canberra, Australia).

179

180 *Movement Profile Classification.* Movement profile classifications have been described
181 for game analysis in similar contact team sports (19,20,23,24), however the
182 classification profile utilized in the present study was devised for American football
183 players. Each movement classification was coded as one of four speeds of locomotion
184 (Table 2). Low-intensity movements, such as standing, walking and light jogging, were
185 considered to be 0 - 10 km·h⁻¹, moderate-intensity movements, such as a cruising jog,
186 were considered to be 10.1 – 16.0 km·h⁻¹, high-intensity movements, such as fast jog or
187 striding, were classified as 16.1 – 23.0 km·h⁻¹, and sprinting or maximal effort
188 movements were classified as exceeding 23.0 km·h⁻¹. Short duration high-intensity
189 movement efforts, or measures of acceleration and deceleration, were classified as
190 three groups, specifically, moderate (1.5 – 2.5 m·s⁻²), high (2.6 – 3.5 m·s⁻²) and maximal
191 (> 3.5 m·s⁻²) and presented as a count of how many efforts an athlete undertook per
192 game.

193

Insert Table 2 Here

194

195 **STATISTICAL ANALYSES**

196

197 All movement and variables from the present study were presented as descriptive
198 statistics, mean \pm standard deviation (SD). Hypothesis testing was conducted to
199 determine any main effects for movement profile data between position groups on the
200 offensive and defensive teams. A one-way ANOVA was used to determine positional
201 group main effects. In the event homogeneity of variance assumption was violated, a
202 Welch Robust Test of Equality was used to determine main effects between position
203 groups. For all main effects detected by a one-way ANOVA, post-hoc Bonferroni tests
204 were utilized. Alpha intervals for all hypothesis testing were set at $p < 0.05$ as the level
205 of significance for statistical tests. All statistical analyses were performed using the
206 Statistical Package for the Social Sciences (SPSS for Windows, version 14.0; SPSS,
207 Inc., Chicago, IL. USA).

208

209 **RESULTS**

210

211 *Offense:* Significant ($p < 0.001$) main effects from ANOVA testing were reported for all
212 movement profile variables measured in the present study for the offensive position
213 groups (Table 3). From post-hoc analysis of movement profile variables, total distance,
214 moderate-intensity distance, high-intensity distance and sprinting distance covered by
215 the WR position was significantly ($p < 0.001$) greater in comparison to all other offensive
216 position groups, including RB, QB, TE, and OL. Low-intensity distance covered by the
217 WR position was also significantly ($p < 0.001$) greater for all offensive position groups
218 apart from QB. The QB position group covered significantly ($p < 0.001$) more low-

219 intensity distance than RB, TE, and OL positions. Moderate-intensity distances were
220 significantly ($p < 0.05$) greater for RB and QB position groups compared to TE and OL
221 position groups. High-intensity distances were significantly ($p < 0.01$) greater for the RB
222 and TE positions compared to QB and OL positions. Sprinting distances were
223 significantly ($p < 0.001$) greater for RB compared to OL. The average max speed
224 achieved by WR, RB and QB positions was significantly ($p < 0.05$) greater than TE and
225 OL positions, while the average max speed achieved by WR position group was
226 significantly ($p < 0.05$) greater than the RB position group.

227

228 For all high-intensity movement profile variables, including sprint efforts, moderate-,
229 high-intensity, maximal-intensity acceleration and deceleration efforts, the WR position
230 was involved in significantly ($p < 0.01$) more efforts than any other offensive position
231 group. The QB and RB positions were involved in significantly ($p < 0.01$) more sprint
232 efforts per game compared to TE and OL positions. The TE and OL groups were
233 involved in significantly ($p < 0.001$) more moderate acceleration efforts than the RB and
234 QB positions; however, the OL position group had significantly ($p < 0.001$) less maximal
235 acceleration efforts compared to QB and RB positions. The OL position was also
236 involved in significantly ($p < 0.001$) more moderate deceleration efforts compared to the
237 RB position, while for maximal deceleration efforts the OL position was involved in
238 significantly ($p < 0.05$) less than the RB and QB position groups.

239

240

Insert Table 3 Here

241

242 *Defense:* Significant ($p < 0.001$) main effects from ANOVA testing were reported for all
243 movement profile variables measured in the present study for defensive position groups
244 team (Table 4). Post-hoc analysis of movement profile variables including total distance,
245 moderate-intensity distance, high-intensity distance and sprinting distance covered,
246 revealed that both the DB and LB positions covered significantly ($p < 0.05$) greater
247 distances in all zones than the DE and DT positions during games. The only main effect
248 reported for distance covered between the DB and LB position groups was for low-
249 intensity distance covered, with the DB position covering significantly ($p < 0.05$) more
250 than the LB position group. The DB position had the highest average max speed which
251 was significantly ($p < 0.05$) greater than all other defensive positions. The average max
252 speed of the LB position group was significantly ($p < 0.05$) greater than DE and DT
253 positions, although significantly ($p < 0.05$) less than DB. The DE position average max
254 speed was significantly ($p < 0.05$) greater than the DT position, and significantly ($p <$
255 0.05) less than DB and LB positions.

256

257 The DB position group was involved in significantly ($p < 0.05$) more sprint efforts,
258 moderate-, high-, and maximal-intensity acceleration and deceleration efforts, than the
259 DE and DT positions groups. Apart from moderate acceleration and deceleration efforts
260 and high-intensity deceleration efforts, the DB position group was involved in
261 significantly ($p < 0.05$) more high-intensity movements than the LB position group. The
262 LB position group was involved in significantly ($p < 0.05$) more sprint efforts, high- and
263 maximal-intensity acceleration and deceleration efforts than the DE and DT positions.

264 Lastly, the DE position group was involved in significantly ($p < 0.05$) more high-intensity
265 acceleration efforts than the DT position group.

266

267 ***Insert Table 4 Here***

268

269 **DISCUSSION**

270

271 The present study examined the competitive physiological movement demands of
272 NCAA Division I college football players using portable GPS technology during games,
273 and assessed positional groups within offensive and defensive teams, to determine if a
274 player's physiological requirements during games are influenced by playing position.

275 The results of the present study provide novel insight into the competitive demands
276 experienced by NCAA Division I college football players, and provide scope for the
277 design of position-specific and game-specific physical conditioning strategies for
278 coaches seeking to optimize training for the demands of competition. The results
279 confirm our hypothesis that significant differences in movement profiles accompanying
280 NCAA Division I college football games exist between playing positions. The most
281 notable finding for physical characteristics of games in both offensive and defensive
282 teams were the movement profiles of the WR, DB, and LB positions, with athletes in
283 these three position groups covering more total distance at higher intensities compared
284 to all other positions on their respective offensive and defensive teams.

285

286 The total distance covered by athletes in team-sport competition such as American
287 football, may be considered an overall reflection of running volume. The present study
288 found a significant ($p < 0.001$) difference in total distance traveled between position
289 groups within both the offensive and defensive teams. The WR position group covered
290 more total distance per game than all other offensive groups. Similarly on defense, the
291 DB and LB position groups covered greater total distance than the DT and DE position
292 groups. The finding of the present study that the WR, DB, and LB position groups
293 covered greater total distance, is consistent with the work of DeMartini et. al. (8) that
294 found significant differences in distance traveled between linemen (2573 ± 489 m) and
295 non-lineman (3532 ± 943 m) during pre-season training. However, the present study
296 evaluated game data over the course of twelve games compared to DeMartini et. al. (8)
297 who evaluated data obtained during pre-season training in the heat. The absence of
298 published research in relation to the demands of NCAA Division I football games make
299 comparisons with others problematic. Despite the absence of comparable studies, the
300 present results indicate that the total distance covered for both linemen (3314.0 m) and
301 non-linemen (4141.3 m) during games are greater than those data reported by
302 DeMartini et. al. (8). From an observational perspective, results from the present study
303 are potentially due to the distance away from the line of scrimmage where the WR, DB
304 and LB position groups started plays. Beginning play further from the line of scrimmage
305 gives athletes a larger area for movement, providing an increased movement
306 requirements during plays and further distances to travel between plays to huddle for
307 brief tactical discussion related to subsequent play. Given WR, DB and LB covered

308 greater total running distance throughout games than their offensive and defensive
309 teammates, it is reasonable to suggest athletes in these positions may require modified
310 running volumes in training to support recovery and adequately prepare them for the
311 physical demands of subsequent competition.

312

313 In addition to differences in total distance covered by WR, DB, and LB, the present
314 study found significant ($p < 0.05$) differences in moderate-intensity, high-intensity, and
315 sprint distances covered by WR, DB, and LB compared to all other positions on their
316 respective teams. The RB and TE covered significantly ($p < 0.05$) more high-intensity
317 distance than OL. Similar observations in American football training were made by
318 Demartini et. al. (8) who reported non-linemen covering significantly ($p < 0.001$) more
319 high-intensity ($> 16.0 \text{ km}\cdot\text{h}^{-1}$) distance for position drills, team drills, and total practice
320 time than linemen in pre-season training. Positional differences observed in the present
321 study may be attributed to the position-specific requirements of games. Tactically, the
322 primary responsibility of OL is to block defensive players, preventing opponents from
323 tackling their own team's ball carrier. These movements are associated with short
324 bursts of acceleration, deceleration, and change of direction, which most frequently
325 occur within a few yards of the line of scrimmage, thereby limiting the distance traveled
326 per play. Players in the DT and DE position groups characteristically accelerate short
327 distances and perform rapid change of direction movements before engaging the
328 opposing OL, followed by pursuing the ball carrier. The position-specific requirements
329 of the OL, DT, and DE positions, requiring a static play initiation posture at or near the
330 line of scrimmage at commencement of each play followed by contact with an opponent

331 positioned approximately one meter apart, likely influences subsequent running
332 distances. These distances are less than that covered by other positions on the
333 offensive and defensive teams that require players to travel greater distances prior to
334 engaging an opponent. The differences in high-intensity distance covered by TE and
335 RB, compared to OL, may be attributed to the more diverse requirements of these
336 position groups, including blocking, running with the ball, and releasing on pass routes.
337 The WR position group is required to repeatedly run passing routes at high velocities
338 throughout the course of games, consequently accounting for significantly greater high-
339 intensity distance and significantly more sprint efforts when compared to all other
340 offensive positions. The DB position group is primarily responsible for defending WR on
341 passing routes, however they also provide secondary support on running plays. As the
342 last line of defense, the DB position is often responsible to make tackles on long running
343 or passing plays, which is indicated in the current study with greater high-intensity
344 distance and more sprint efforts of DB when compared to all other defensive positions.

345

346 In addition to the distance covered during play, the WR and DB cover more distance
347 between plays as they are required to jog back to the line of scrimmage at the
348 conclusion of plays, which may be a distance 20-30 m to either huddle or re-assume
349 their alignment for subsequent play, whereas OL, DT, and DE characteristically walk
350 short distances during recovery between plays (26). The LB position is required to
351 defend running plays in addition to covering WR, RB and TE on passing plays which
352 may account for similar movement characteristics to the DB position. The results of the
353 present study highlight the unique movement demands of WR, DB and LB position

354 groups in comparison to other positions on their respective offensive and defensive
355 teams, and is potentially related to their proximity to the line of scrimmage at the
356 initiation of play. Young et. al. (32) reported greater running distance covered at high
357 speed, along with moderate and high accelerations and decelerations to be associated
358 with markers of muscle damage in collision team-sport players, and consequently, the
359 monitoring and prudent adjustment of weekly training loads of the WR, DB and LB
360 position groups specifically, may reduce the likelihood of subsequent performance
361 decrements associated with fatigue.

362

363 Research (1,21,24) in team-sports utilizing portable GPS technology indicate positional
364 differences in movement characteristics during competition. No previous studies have
365 reported the movement demands of NCAA Division I football competition, consequently
366 a lack of understanding exists regarding the demands of American football games.
367 Investigations in team sports similar to American football, including rugby league, rugby
368 union, and Australian rules football, indicate significant differences exist in high-intensity
369 movements including acceleration and deceleration efforts (28,32), and maximal speed
370 (5,24) between position groups. The present study found significant differences in
371 maximal running speeds and maximal acceleration and deceleration efforts recorded
372 from offensive position groups. The average max speed of WR position was
373 significantly ($p < 0.05$) greater than all other offensive positions except QB. The RB and
374 QB position groups average max speed was significantly ($p < 0.05$) greater than that of
375 both the TE and OL position groups. The WR group had significantly ($p < 0.05$) more
376 sprint, maximal acceleration, and maximal deceleration efforts than all other offensive

377 position groups, presumably do to repeated route running requiring sprinting and
378 frequent changes of direction.

379

380 Defensively, there were no significant differences between total, moderate-, or high-
381 intensity distance covered between DB and LB position groups, however, significant (p
382 < 0.05) differences were indicated for average max speed, sprint, maximal acceleration,
383 and maximal deceleration efforts. The DB group had significantly ($p < 0.05$) more
384 sprint, maximal acceleration, and maximal deceleration efforts than all other defensive
385 positions, highlighting the specific high-intensity running requirements of this position
386 during defensive play. The LB position group demonstrated significantly ($p < 0.05$)
387 greater average max speeds, sprint, maximal acceleration, and maximal deceleration
388 efforts than the DE and DT groups. Similar research (8) has not quantified high-
389 intensity movement characteristics of individual position groups, making comparisons
390 with the present study difficult.

391

392 The significant differences between the DB group when compared to the defense as a
393 whole, and the LB compared to DT and DE, highlight three distinct running profiles for
394 the defensive team, requiring different forms of training to achieve optimal development.
395 The starting positions upon commencement of each play for the DB and LB groups
396 afford larger areas to achieve higher max speeds, while the positional requirements of
397 defending pass routes and pursuing ball carriers result in greater changes of direction
398 for the DB and LB groups. The WR and DB position groups achieved significantly

399 greater max speeds, sprint efforts, and maximal acceleration and deceleration efforts
400 than their respective offensive and defensive counterparts throughout the course of
401 games, indicating the need for positional specificity in speed training for NCAA Division I
402 football players.

403

404 The results of the present study provide novel insight into position-specific physical
405 demands of NCAA Division I football games and provide physical performance staff with
406 quantified information, which can potentially be used to replicate the physical demands
407 of games in training. The present study demonstrated appreciable differences in the
408 positional movement demands of NCAA Division I college football games, emphasizing
409 the need for position-specific training to adequately prepare players for the rigors of
410 competition.

411

412 **PRACTICAL APPLICATIONS**

413

414 The present study provided a novel analysis of the movement demands associated with
415 NCAA Division I college football games. The results indicated significant differences in
416 total running volume and high-intensity movement demands, most notably for the WR,
417 DB, and LB position groups. Higher overall running loads were experienced for these
418 three position groups, while greater high-intensity movement demands were required of
419 the WR and DB groups. Data from the present study augments our understanding of the
420 competitive demands experienced by NCAA Division I college football players, and

421 provides scope for the design of position-specific and game-specific physical
422 conditioning strategies for coaches seeking to optimize training for the demands of
423 competition.

424

425 Data from the present study support the use of position-specific training in the
426 preparation of NCAA Division I college football players for competitive games.
427 Maximizing performance and limiting the effects of fatigue are critical challenges for
428 performance coaches, and as such, accounting for the physical demands associated
429 with weekly training and games is imperative. Modifying weekly training loads of
430 individuals within position groups involved in greater high-speed running volumes and a
431 higher number of acceleration and deceleration efforts may mitigate fatigue, accelerate
432 recovery, and improve subsequent performance. The WR, DB, and LB position groups
433 are exposed to greater running volumes, faster running velocities, and a higher number
434 of acceleration and deceleration efforts in games compared to their offensive and
435 defensive counterparts, and may benefit from carefully monitored and individualized
436 training load prescriptions throughout the week. Additionally, while RB and TE groups
437 do not accrue the total distances during games of the WR group, they are exposed to
438 greater running volumes than the OL, warranting individualized training load
439 prescriptions governed by the physical demands of competition. Clearly, performance
440 coaches seeking to optimize physical performance characteristics associated with
441 competition must differentiate training programs based upon position-specific movement
442 demands.

443

444 Data obtained from the present study provide a better understanding of the demands of
445 NCAA Division I football and provide a foundation from which to implement a systematic
446 approach to the development of individual and position-specific training programs.
447 Future studies should examine how coaches seeking to enhance competitive
448 performance, can manipulate individual and position-specific training programs to
449 mitigate fatigue, enhance recovery, and optimize game-day performance.

450

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452

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455 endorsement of the product by the authors of the National Strength and Conditioning
456 Association.

457

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