THE RELATIONSHIP BETWEEN OFFSEASON TESTING AND GAME PERFORMANCE OF DIVISION I COLLEGIATE FOOTBALL PLAYERS

by

Garrett VanHoy

A Senior Honors Project Presented to the

Honors College

East Carolina University

In Partial Fulfillment of the

Requirements for

Graduation with Honors

by

Garrett VanHoy

Greenville, NC

May 2017

Approved by:

Mr. Dave Kemble

Department of Kinesiology, College of Human and Health Performance

Table of Contents

ABSTRACT

Offseason football strength programs consist of three distinct areas of training: speed/agility/quickness (SAQ); strength/power; and flexibility. These areas have been predetermined to be of most relation to football (Sawyer, Ostarello, Suess, & Dempsey, 2002). The results of these tests determine which players are the best athletes, subsequently labeling them with the potential to be the best football players. Personal football experience has revealed that excellent players may not test well and excellent testers may not perform well in games. It was hypothesized that offseason testing results would not be strongly related to game performance, but the 40-yard dash and the vertical jump would be the best indicators of how players perform. The purpose of this research was to examine the relationship between offseason testing results and game performance of Division I Collegiate Football players.

The football strength staff at East Carolina gave a test battery to the players during the offseason. This study used the data collected to form correlations with game performance from the 2016 East Carolina Football season. Each category of testing was evaluated to determine if certain tests are better indicators of game performance than others. The research focused on a specific position group, defensive backs, in order to improve reliability of results.

The hypothesis was not fully supported because the vertical jump produced a strong correlation to game performance (r = 0.76), rejecting the first part of the hypothesis that no offseason test would strongly correlate. The second part of the hypothesis was supported because the vertical jump was the best indicator of game performance. The data suggests previous literature was correct in providing an indication of the results from which the

vertical jump test was the strongest correlated offseason test with game performance. The broad jump and flexibility were tests that produced moderate correlations. Z-scores were calculated for all player testing to provide a normalized indication of athletic performance. These correlations could be specific to the defensive back position and other position groups may yield different results.

BACKGROUND

College football is watched by millions of people each week. At East Carolina University, the football team is one of the most recognizable aspects of the entire university. It is imperative that the team is as successful as possible, but success does not happen for any football team without quality recruiting and player evaluation. Hard work and determination from the players, coaches, managers, and trainers are needed all year in order to field a successful team. Strength and conditioning programs are needed to train players in the offseason so they will become better athletes with an improved ability to perform during games. Increased athleticism is the overall goal of strength and conditioning programs (Hedrick, 1996).

Offseason football strength programs consist of three distinct areas of training: speed/agility/quickness (SAQ); strength/power; and flexibility. Coaches spend countless hours evaluating players and recruits on these specific areas that underlie the ability to play football. These areas have been predetermined to be of most relation to football (Sawyer et al., 2002). The results of these testing areas determine which players are the best athletes, which subsequently labels them with the potential to be the best football players. In a survey conducted by Roundy (1994), it was found that players who score higher on strength, power, and speed tests were more likely to be starters. It is important to know which tests are the best indicators of game performance and it matters because it can show if the best athletes make the best football players. Testing results may vary depending on the football position group, so it is important to highlight which tests are better indicators of performance specific to that position. For example, a defensive lineman requires more strength and power to rush the quarterback, while a wide receiver requires more speed and agility to gain separation from defenders while executing passing routes. It would be inaccurate to give a general predictive test across all position groups due to the varying nature of football player abilities in relation to position.

Speed, agility, and quickness are the terms used to describe how well a player moves. All three of these areas of athleticism are very important in the sport of football (Sawyer et al., 2002). These three elements are often compiled to create a SAQ training method (Jovanovich, Sporis, Omrcen & Fiorentini 2011). They are placed together because their respective tests can be used to improve each of those areas of athleticism. SAQ training can be effective for strength coaches involved in team sports that emphasize quickness and acceleration over maximal speed. This is important because SAQ training improves quickness and acceleration, which has been shown to improve power performance in team sports where those areas are emphasized (Jovanovich et al., 2011).

Ebben (1998) stated that speed is defined as the rapidity of movement. The 40-yard dash is one of the most common speed tests used by football programs. This short sprint test is important for football because anaerobic systems are more commonly used during the course of a football game, rather than longer aerobic exercises (Ebben, 1998). Previous testing has shown that the 40-yard dash is the preferred method of testing by football coaches and that the test is likely to show that it is the best indicator of football playing ability (Ostarello, 2008). This has been shown in spite of the fact that football players rarely sprint for forty yards at a time in a straight line. Running speed, exemplified by the 40-yard dash, is an element of football that is of higher importance for the football positions of Wide Receiver (WR) – Defensive Back (DB) – Running Back (RB) – Tight End (TE) – Linebacker (LB) (Sawyer et al., 2002). This test is the preferred method to measuring and evaluating the speed of a football player. It is often looked at with more scrutiny than any other test and can make or break a player's position on the team. Evaluators at the NFL Combine view this test as the way for prospects to make the team.

Agility is the ability to stop, start, and change direction of movement according to Ebben (1998). Agility is normally tested by football programs through an array of drills that assess quick changes of direction. The most common agility drills are the 3-cone drill and pro shuttle. Each of these drills are emphasized at the NFL Combine. Football movements rarely involve straight line sprints, but instead rely heavily on the ability to quickly change directions. For this reason, reactive movements and agility are important physical abilities for success in playing football (Ebben, 1998). An athlete's agility can be improved by completing plyometric training (Miller, Herniman, Ricard, Cheatham & Michael, 2006). Miller (2006) explains that plyometric drills consist of stopping, starting, and changing direction in an explosive method. This is similar to the agility requirements of many football positions, particularly skill positions like wide receiver and defensive back. The agility study by Miller also provided results that support the use of plyometric training during the final weeks of preparation for the in-season competition in order to improve agility. This information on agility testing is important because football strength and conditioning programs may want to incorporate plyometric training into the training regimen of the football positions that correlate agility to game performance.

Increased strength and power is a major goal for football strength and conditioning programs (Hedrick, 1996). Strength and power training has been shown to decrease the amount of time needed for an athlete to achieve peak power output (Christian, Seymour, 1985). Fast twitch muscle fiber development and modifications to the central nervous system motor neurons are the physiological changes needed to observe the decreased time for peak power. Football is a sport that is reliant upon the use of fast twitch muscle fibers. These fibers can be tested by strength tests such as the bench press and back squat. The development of fast twitch fibers allow a football player to achieve peak power at a faster rate and be able to sustain that power for longer periods of time (Christian et al.,1985). Testing results that demonstrate higher wattage rates and higher lift values should indicate an individual has higher amounts of fast twitch fibers (Christian et al., 1985). Fast twitch muscle fibers are also responsible for quick reactive movements. This is important to football because the faster a defensive lineman moves at the snap of the ball, or the quicker a cornerback breaks on a route by a wide receiver, the better it will be able to directly lead to the success of the individual player. One repetition maximums of the bench press, squat, and power clean are common methods of measuring strength and power in Division I Football Players (Nesser, Huxel, Tincher & Okada, 2008).

While strength and power can be viewed together, they can also be separated. Strength is the first focus of a weight program because it is important to the process of increasing muscle power, still exemplifying how the two areas are closely intertwined. The bench press and back squat are lifts to indicate strength (Hedrick, 1996). They are slow lifts with one axis of movement. The bench press and other strength tests have been shown to contribute to game performance with a minimal effect in spite of their high usage rates and prevalence in football strength and conditioning programs (Sawyer et al., 2002). Excelling at strength testing does not guarantee excellent football playing ability. Players must be able to translate all areas of offseason testing to season competition.

Power is an important component of athletic performance. The ability to exert force at relatively high speeds is muscular power (Ebben, 1998). Power testing can be viewed as having strength with the ability to incorporate speed into the movement. Power testing helps develop fast twitch fibers by allowing a football player to achieve peak power at a faster rate sustaining that power for longer periods of time. These fibers can be tested by power tests such as the power clean, vertical jump, and broad jump. The power clean is a test that combines the strength of muscle fibers and their fast twitch ability. It is also a better indicator of upper body power, something that is critical for football performance (Ebben, 1998). The vertical jump and broad jump assess lower body power and are more indicative of strictly the power aspect of a player. These lower body power tests consist of rapid and powerful plantar flexion of the ankle that is combined with rapid and powerful extension at the knee and hip (Sawyer et al., 2002). According to Hedrick (1996), the "power zone" consists of the quadriceps, hamstrings, gluteals, abdominals, and erector spinae. These muscle groups are trained by power cleans and plyometrics and are crucial to athletic performance. The vertical jump has emerged as a strong predictor of game performance and better football players possess greater vertical jumping ability (Sawyer et al., 2002). The importance of the vertical jump is evident through its incorporation into multiple testing protocols when determining relationships between field tests and game performance (Rampinini et al., 2007).

Flexibility is an area of fitness training that is often emphasized with lesser importance when compared to SAQ, strength, and power. However, there are still important components to flexibility that can be used to improve the football playing ability of an athlete. Flexibility can be trained through acute and chronic stretching. Acute stretching may have a negative impact on performance while chronic stretching may improve flexibility and performance (Stone et al., 2006). Chronic stretching may also reduce injury potential, something that is vital to football players where injuries are more common than other sports. Flexibility is defined as the range of motion around a joint (Shellock & Prentice, 1985). Many sources have reported that flexibility was not assessed during testing of football players. Within the sources that reported flexibility testing, there were two methods that were used: the incorporation of multiple tests or the focus on the sit-and-reach test (Ebben, 1998). The sit-and-reach is a test of flexibility that is largely used to examine hamstring and lower back flexibility (French, Grayson, Sanders, Williams & Ward, 2016). Sources have also showed us that flexibility is important in the prevention of injuries, so football players should consequently perform flexibility exercises (Allerheiligen, 1994). Testing in the area of flexibility would allow a coach or researcher to assess the improvements made in the player's flexibility development. The ability of a player to bend can have a large effect on the agility of a player. A player with more flexibility in the hips and hamstrings can greatly improve their ability to have a quick change of direction because changing direction in a football movement requires bending of the hips and knees.

Purpose

It was hypothesized that offseason testing results would not be strongly correlated to game performance, but the 40-yard dash and the vertical jump would be the best indicators of how players perform. This two part hypothesis was researched with the purpose to examine the relationship between offseason testing results and game performance of Division I Collegiate Football players. The results of SAQ, strength, power, and flexibility tests during summer training were compared to game performance in the fall. Each category of testing was analyzed to determine if certain tests were better indicators for game performance than others. Coaches can place more emphasis on tests that produced a higher correlation to game performance and less emphases on the tests that did not correlate well.

METHODS

Participants

Participants in this research included American football players from a NCAA Division I-FBS school located in the southeastern U.S.A. Defensive backs, to be position specific, were the players that were selected to participate in the research. The similarities and skill set of all the defensive backs allowed for a better comparison of results, thus increasing the reliability. A total of 10 defensive backs were included in the research and they ranged from the classification of freshman to redshirt senior. A requirement for data inclusion is that the player participates in at least 8 out of the 12 games (67%). This inclusion requirement reduced the number of defensive backs to 6. The football program at this school uses a strength and conditioning staff to train and test its players. The leader of the strength staff is Jeff Connors, who has been honored as a Master Strength & Conditioning Coach by the Collegiate Strength and Conditioning Coaches association (CSCCa). The Master Strength & Conditioning Coach certification is the greatest honor that can be achieved as a strength and conditioning coach. The honor represents professionalism, knowledge, experience, expertise, and longevity in strength and conditioning. In 2016, Connors was inducted into the USA Strength & Conditioning Hall of Fame. He also received recognition as The College Strength and Conditioning Coach-of-the-Year for 2017 by The National Strength and Conditioning Association.

Protocol

The testing was performed during April of 2016, while game performance was measured during the 2016 season, ranging from September to December. All testing procedures were performed on players with prior knowledge. All tests were explained by the strength and conditioning staff to minimize testing errors. Game performance was evaluated with a video monitoring software that incorporated the use of three camera angles. Each game film is cut up into individual plays with the camera angles grouped together. Coaches watch and grade each play multiple times to make sure the grading is accurate. The multiple camera views and video playback options with the software allow for more accurate grading as well. Rampinini (2007) used a similar construction for testing the validity of field tests as indicators of match-related physical performance in top-level professional soccer players. Field tests like the vertical jump were collected in a strength and conditioning setting while the game performance data was measured using video capturing software.

Strength information was gathered through the tests of the 1-RM bench press, and the back squat. The **1-RM bench press** was a test performed by the player where they had to successfully lift a weight one time with proper technique. The player was placed in a supine position on a bench with the knees bent and flat on the ground (Calatayud, et el, 2015). The head and trunk of the player was supported by the bench. The player was required to lift the bar off of the rack and bring it down to touch the chest, then lift the bar back to a full extension of the arms before re-racking. If the lift was successful, the player rested 2-4 minutes before adding 5-10% more weight and performing the 1-RM an additional time. The repetition that was successfully performed with the most weight was the score that was recorded for the player. The **1-RM back squat** was another test performed by the player where they had to successfully lift a weight one time with proper technique. The lift was performed by starting in the standing position with the weight placed on the back of the shoulders behind the head. The player descended towards the ground in an eccentric motion until a 90-degree angle was achieved at the knee (Hester, Conchola, Thiele & DeFreitas, 2014). The player then returned to the standing position through the concentric motion of pushing off the ground, concluding the lift. Successful lifts required an addition of light loads. The 1RM was determined in less than 5 trials, with each subject being allowed a 3-minute rest period between trials (Hester et al., 2014).

Power was measured using the tests of the power clean, vertical jump, and standing broad jump. The **power clean** was a lift where the barbell was in the starting position on the ground. The player started in a squatting position to get better leverage for the initial pull phase. Once the bar was quickly pulled up, the player began to move their hips forward and bend slightly at the knees in order to prepare for moving their body under the bar. After the player pulled their body under the bar they had to get into a slight squat while keeping the bar close to the body. This allowed the player to complete the lift by standing up with the bar still held across the shoulders. The player slowly lowered the bar to the ground after reaching the standing position (Sawyer et al., 2002). The **vertical jump** was a two-footed takeoff used with no approach steps. The score was determined by measuring the difference between a fully extended standing reach and a maximal vertical jump reach. The standing reach was recorded by instructing the player to stand flat on the ground with one arm vertically extended. The same arm was used for the vertical jump trials. A Vertec vertical jump measuring device like the one used by Nesser (2008) was used to measure the maximal height obtained. Two trials were performed and the best score was recorded (Schmidt, 1999). The **standing broad jump** was a test of power in the lower body. Horizontal jump distance was measured from a two-footed stance in the standing position. The player flexed at the knees and rapidly extended for maximal jump distance. Jump distance was measured from the start line to the part of the body that landed closest to that line (Robbins, 2010).

Speed was measured using a 40-yard dash. The **40-yard dash** was a test where the player aligns in a three-point stance behind a start line. The objective was to run through forty yards as fast as possible. The run was manually timed with a stopwatch and the timers started at the first movement of the player out of their three-point stance. The time stopped once the player crossed the 40-yard mark (Robbins, 2010).

Agility data was gathered by testing the pro shuttle, L-drill, and the 60-yard shuttle. The **pro shuttle** was constructed with measurements comparable to those used by Nesser (2008). A total distance of ten yards was measured with a midpoint line at five yards. The players straddled the midpoint line for the starting position. The next step consisted of the player running five yards in the right horizontal direction from the midpoint to reach the right 10-yard marker. The player then ran to the left 10-yard maker before changing direction one more time to run through the 5-yard midpoint line. Time was started with the initial movement to the right 10-yard marker and concluded once the player crossed the 5-yard midpoint line. The pro shuttle is a test of horizontal speed by requiring the execution of multiple horizontal movements (Robbins, 2010). The **L-drill** was a test consisting of three cones, placed in the shape of an "L", with five yards of separation between them. The players started in a three-point stance and ran around the cones in that same "L" shape as quickly as possible. It was important that the player finished the drill running past the cone that they initially started from (Robbins, 2010). The **60-yard shuttle** was a timed run where the player started in a three-point stance and sprint forward twenty yards and then back in the opposite direction for twenty yards. After returning to the initial starting point, the player sprinted forward ten yards and then sprinted back another ten yards in the opposite direction to conclude the test.

Flexibility was measured using multiple tests of flexibility to produce a combined flexibility score. The three flexibility tests administered were an overhead squat, active straight leg raise, and the sit-and-reach test. Each test focused on different aspects of flexibility that are important to football playing ability. The first test given was the overhead squat. This is a complex flexibility test that measures a player's ability to bend while maintaining posture. The player must hold a bar above their head while performing a squat motion with their heels flat on the ground. The hips and knees should exhibit flexion similar to squat depth. The player can score from 0 to 3 on this test. A perfect score of 3 indicates that the player could keep their heels flat on the ground while properly executing the overhead squat with satisfactory balance and a maintained posture. A score of 2 is given if the heels of the player come off of the ground through ankle dorsal flexion. This requires an approximately 5x15 cm board to be placed under the heels. If the athlete is still not able to execute the overhead squat they receive a score of 1. A score of 0 is awarded if the player complains of pain during the movement. A doctor must be consulted before the player is allowed to participate in football related activities.

The second test given was the active straight leg raise. This test focuses on hamstring flexibility and can determine if hamstring flexibility is related to their performance on the overheard squat. Each leg is measured independently so that hamstring flexibility deficiencies can be isolated to the specific leg. The player was instructed to be in the supine position with full extension of the legs. Scores were given on a scale of 0-3 with levels of proficiency of the movement determining the score awarded. A player given a 3 is able to raise their leg above a stick positioned from the top of the hip down to the middle of the knee. A 2 is given to a player that was able to raise their leg above a stick positioned from the midpoint of the thigh to the patella.

The third test given, the sit-and-reach test, consisted of a protocol where the player sat on the floor with their knees flat and ankles dorsiflexed at a 90-degree angle. Shoes were removed and feet were placed flat against a box. The player placed one hand on top of the other and reached forward as far as possible while keeping their knees on the floor. The box was marked in inches to determine the farthest distance that the player could reach past their toes and hold for at least one second (French et al., 2016). The numerical score awarded to the player is the number of inches reached past the toes. For example, the player receives a score of -2 if they can only reach to a point that is 2 inches short of their toes. The three test scores are then summed and a total score is given as the offseason testing score for flexibility.

The method for measuring game performance was using a player grade sheet to evaluate the defensive backs after each game. Football players are graded at the conclusion of each game much like a student is graded with an exam. Coach Rick Smith developed the grade sheet that was used for measuring game performance. He has over forty years of coaching experience at the Division I-FBS level, thus giving the test expert validity.

The grade sheet consists of a wide range of categories to cover nearly every aspect to playing defense in the game of football. This allows for a more thorough evaluation of the players. The categories that result in a positive score are: tackles (+2), assisted tackles (+1), tackle for loss (+3), sacks (+3), quarterback pressures (+1), interceptions (+5), pass break up (+1), big hit (+1), forced fumbles (+3), fumble recoveries (+2), and defensive score (+12). The categories that result in a negative score are: loaf (-2), missed tackle (-2), missed assignment (-3), penalty (-5), and give up score (-3). The categories that can be viewed as objective or opinionated are big hits (+1), and loafs (-2), with all of the remaining categories being non-objective. This research also recognizes that some of the categories may be a non-objective statistic, but can result from the objective view of the human element. The most obvious example is the category for a penalty (-5) where a referee can make a judgment call that can be either correct or incorrect. An incorrect call can unfairly result in a negative grade for the player. The large sampling size for grading helps to eliminate any large negative effects that an error in refereeing may cause to the player.

The total grade for a player is typically within the range of 80-110 points. The scores are viewed as either “winning” or “losing”. A “winning” score for the defensive back position of safety is >85 and a “winning” score for a cornerback is >91.

<u>Data Analysis</u>

The offseason testing data was recorded into a Microsoft Excel document by strength coach assistants. The game performance data was recorded using DVSport Software. This is a type of software that allows football coaches to watch and review game film. Coaches evaluate the players’ performance on what the film shows. There are many tools available to the coaches within the software that allows the grading to be more accurate. The grading sheet being used in this research was completed using DVSport Software.

Each offseason test for each player was assigned a z-score. Z-scores were calculated by subtracting the mean test score from the specific player’s test score, then dividing by the standard deviation. Z-scores are also a method of normalizing all of the various testing values into one standard value that can be used across the array of offseason tests. Mean z-scores were calculated for each player and subsequently provided a rank number. A z-score rank was produced for each test and for the mean z-score. A positive z-score exemplifies a test score that is higher than the group, while a negative z-score indicates a test score that is lower than the group.

The final game performance grades were recorded for each player throughout the season. The mean game performance was calculated at the conclusion of the season. These values were then used to calculate correlations with each z-score that corresponded to the offseason test that the player completed. A Pearson Correlation with r was used and analyzed with IBM SPSS Statistics software. The variables in the SPSS data set were all numerical and had to be kept in pairs, but the order of the pairs were not important. The study evaluated the correlations as being low (r = |0.0 – 0.29|), moderate (r = |0.3 – 0.59|, or high (r = |0.6 – 1|).

A deeper analysis of the data was conducted to see if there were any differences in meaningful tests during the progression of the season. The season was broken up into four-game increments to observe which tests were more correlated to the beginning, middle, and end of the season.

RESULTS

Descriptive measurements and scoring are reported in Table 1. The measurements are reported for six players because the original ten participants were restricted due to the necessary game participation requirements. Only six of the ten players had participation in eight out of the twelve season games. Height (Ht) was recorded for each participant in centimeters and weight (Wt) was recorded in kilograms. The scoring columns contain the mean z-score (Z) for each player and how they are ranked, with the highest z-score qualifying as the top ranked player. Game performance (GP) mean values were also reported in addition to an overall game performance ranking. Player 1 (P1) had the highest ranked z-score with a value of 1.06 and had the third highest game performance mean of 76 points. Player 2 (P2) produced the only other positive z-score (0.17) and had the highest ranked game performance of 84.3 points. Player 3 (P3) had a z-score of -0.01 and was the fifth highest ranked game performance mean. Player 4 (P4) produced the fourth highest ranked game performance with a grade of 75.5 points and coupled that with a z-score of -0.26. The game performance value of 64.0 points was attributed to Player 5 (P5), the lowest ranked value. They also received the fifth highest z-score. Player 6 (P6) had the lowest z-score of -0.57 and a game performance mean of 77.8 points. There was a difference of 20.3 points from the highest mean game performance to the lowest. The mean z-scores were further correlated to game performance and produced a positive weak correlation of 0.28.

Table 1.

DESCRIPTIVE MEASUREMENTS			SCORING			
	Size		Z		GP	
PLAYER	Ht (cm)	Wt (kg)	M	Total Rank	M	Total Rank
P1	185	84	1.06	1	76.0	3
P2	193	90	0.17	2	84.3	1
P3	178	85	-0.01	3	73.3	5
P4	183	89	-0.26	4	75.5	4
P5	183	78	-0.39	5	64.0	6
P6	180	86	-0.57	6	77.8	2

Table 2 contains the recorded information for each player and the tests they completed. The actual test score (#), z-score, and rank (Rk) were reported for each offseason test. Areas of training were used to further categorize the offseason tests. This table provides the raw data that was used to calculate all means, standard deviations, z-scores, and correlations. 1-RM bench press (BP), 1-RM back squat (BS), and the 1-RM power clean (PC) were measured in pounds. The vertical jump (VJ) and broad jump (BJ) were measured in inches. The 40-yard dash (40YD), pro-shuttle (PS), L-drill (LD), and 60-yard shuttle (LD) were measured in seconds. The flexibility (FLX) test was a collective score of three tests. Player 1 had the highest z-score in 9 out of the 10 offseason tests. This was a top ranking in every test other than the vertical jump. The vertical jump showed a result of player 2 having the highest z-score, while player 1 recorded the second highest z-score.

Table 2.

OVERALL TEST PERFORMANCE

	Strength						Power								
	BP			BS			PC			VJ			BJ		
PLAYER	#	Z	Rk	#	Z	Rk	#	Z	Rk	#	Z	Rk	#	Z	Rk
P1	335	1.07	1	480	1.23	1	316	1.83	1	34.5	0.27	2	122.5	1.09	1
P2	305	0.00	3	400	-0.46	4	274	-0.43	3	39.5	1.86	1	122.0	0.96	2
P3	300	-0.18	4	415	-0.14	3	274	-0.43	3	33.5	-0.05	3	112.5	-1.50	6
P4	335	1.07	1	480	1.23	1	290	0.43	2	31.5	-0.69	5	115.0	-0.83	5
P5	295	-0.36	5	385	-0.77	5	274	-0.43	3	31.0	-0.85	6	118.5	0.06	4
P6	260	-1.60	6	370	-1.09	6	264	-0.97	6	32.0	-0.53	4	119.0	0.19	3

	Speed			Agility									Flexibility		
	40YD			PS			LD			LS			FLX		
PLAYER	#	Z	Rk	#	Z	Rk	#	Z	Rk	#	Z	Rk	#	Z	Rk
P1	4.40	1.05	1	4.01	0.67	1	6.65	1.14	1	11.05	1.45	1	16	0.76	1
P2	4.57	-0.65	5	4.01	0.67	1	6.89	-0.09	4	11.56	-0.07	4	15	-0.07	4
P3	4.52	-0.15	4	4.06	0.13	4	6.71	0.84	2	11.34	0.59	2	16	0.76	1
P4	4.66	-1.55	6	4.25	-1.94	6	6.79	0.43	3	12.02	-1.44	6	16	0.76	1
P5	4.47	0.35	3	4.02	0.56	3	7.05	-0.90	5	11.49	0.14	3	13	-1.74	6
P6	4.41	0.95	2	4.08	-0.09	5	7.15	-1.41	6	11.76	-0.67	5	15	-0.49	5

Pearson Correlations were calculated for each offseason test in Table 2 (see Table 3). There were three offseason tests that were in the range of being at least a moderate correlation. All three of these tests exhibited a positive correlation. The vertical jump, an offseason test of power, had the strongest positive correlation to game performance with a correlation of 0.76. The second largest positive correlation to game performance occurred in the flexibility test. Flexibility reported a high moderate correlation of 0.51. The third correlation belonged to the broad jump, another test of power, and game performance. A low moderate correlation of 0.36 was reported. The two strength offseason tests of the 1-RM bench press and 1-RM back squat reported correlations of 0.04 and 0.10 respectively. Two of the power tests were of at least moderate correlation, but the third power test of the 1-RM power reported a weak correlation of 0.03. The offseason speed test, the 40-yard dash, reported a weak negative correlation of -0.20. None of the offseason agility tests reported a correlation above 0.20, with the L-drill having the largest correlation of the group at 0.16. This is still a weak correlation. The pro shuttle produced a correlation of -0.02 and the 60-yard shuttle produced a correlation of -0.13.

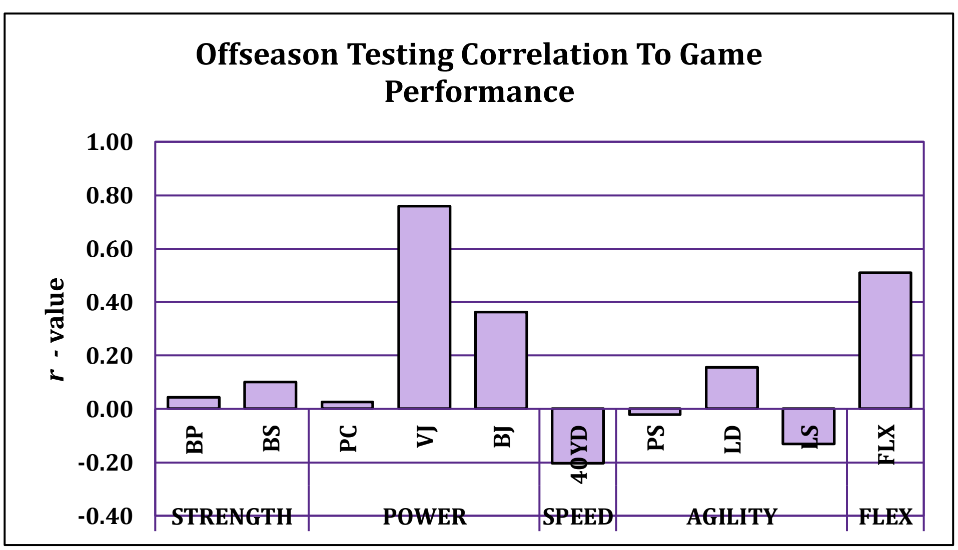
Table 3.

Correlations

		MEAN_GP	BP	BS	PC	VJ	BJ	40YD	PS	LD	LS	FLX
MEAN_GP	Pearson Correlation	1	.043	.101	.026	.760	.362	-.204	-.022	.155	-.130	.511
	Sig. (2-tailed)		.935	.849	.961	.080	.481	.698	.968	.769	.806	.300
	N	6	6	6	6	6	6	6	6	6	6	6

Graph 1 provides a visual representation of each Pearson Correlation. It is apparent that the vertical jump had a much higher correlation to game performance compared to all other offseason tests. Flexibility and broad jump are also clearly defined as having stronger correlations that their offseason testing counterparts. Graph 3 also gives a representation of how the 40-yard dash, pro shuttle, and 60-yard dash are all reported as negative correlations. A negative correlation indicates that lower z-scores on these tests correlated to higher scores of game performance.

Graph 1.



DISCUSSION

The literature suggested that speed and power testing were most important for football playing ability. The data supported the importance of power testing but did not exhibit support for speed testing in the position of defensive back, which encompasses the cornerbacks and the safeties. Two of the three tests that were at least moderately correlated to game performance were power tests. The vertical jump proved to be a highly correlated offseason test with game performance and the broad jump was moderately correlated to game performance. This supported the second portion of the hypothesis that stated the vertical jump would be one of the best indicators of game performance, but rejected the first part of the hypothesis that there would be no strong correlations.

The vertical jump and broad jump are each power tests that rely on the use of fast-twitch muscle fibers. It should be no surprise that defensive backs with high z-scores for each of these test would grade well during game performance. Defensive backs use their jumping ability to deflect and intercept passes thrown in their direction. Situations where jumping ability is imperative to making a successful play occurs frequently throughout a game for a defensive back. A higher jumping ability allows a defensive back to defend more passes and prevent completions, thus producing a better game performance grade. These same fast twitch muscle fibers that are used in the lower body for the vertical jump are also used to quickly adjust from a sprint, backpedal, or directional cut towards the football. The strong and moderate correlations for these tests add to the belief that football is reliant upon the use of fast-twitch muscle fibers in the lower body. Testing and developing these fibers may lead to better game performance at the defensive back position.

The majority of testing did not correlate well with game performance. None of the strength tests produced a correlation higher than 0.10. This can also include the power clean, which was the only power test that did not produce at least a moderate correlation. A possible explanation for this may be the power clean has many strength qualities within the test, as well as requiring a high degree of movement skill. Power cleans require more skill and technique than a single jump. The vertical jump and broad jump are much easier to execute. Speed and agility were the other offseason testing areas that did not correlate well with game performance. The best correlation of the group was the 40-yard dash at a weak negative correlation of -0.20. The negative correlation meant that lower z-score 40-yard dash times correlated to higher game performance grades, which was in disagreement with what the literature provided. This data explains that slower 40-yard dash times correlate to higher game performance. Even though the correlation was weak, the value can still be interpreted as having minimal impact on the ability of a defensive back to perform during games. The 40-yard dash may be given too much importance in comparison to other tests.

The flexibility test is of interest because the literature indicated that many strength and conditioning programs do not place enough emphasis on flexibility testing. When tested, flexibility still may be viewed as of lesser importance to strength and agility testing. These findings exemplify that flexibility, with the second highest correlated test ($r = .51$), should not be ignored. The more flexible players in this study may have been able to rotate their hips in a quicker motion in order to make a positive defensive play on the football. It could also have been a benefit to have more flexible hamstrings when flexing at the knees to make a low tackle on the ball carrier.

A limiting factor in this study was the sample size. A total of 6 participants may have allowed outliers to be a factor in the results, specifically the size of the correlations that were produced. For example, the negative correlation with the 40-yard dash may have been negatively affected by sample size because being a slower player should not improve game performance at any position. The negative correlations for the 40-yard dash, pro shuttle, and 60-yard shuttle would be expected to be at least somewhat positive with a larger sample size. It is important to maintain the game participation requirements in order to preserve reliability of results. Including the results of a player who played one game or a player who only played a few games would introduce outliers into the data set.

Further testing could be implemented by breaking the season down into three segments. It may be revealed that certain tests are more indicative of game performance during specific periods of the season. For example, agility and speed tests may be better indicators for the first part of a season but strength tests many be a better indicator of how a player will perform during the last part of the season. Coaches could use this information to change the workout routine of position groups during a season to better fit the needs of the players and promote game performance by increasing emphasis on those specific tests during that part of the season.

Further testing on other position groups will determine the tests that are better indicators of game performance for their respective position. These results for defensive backs are not likely to be observed for every position. The wide range of descriptive attributes and football playing ability for each player may lead to other tests correlating well to a higher level of game performance. However, it can be deducted that other skill positions (WR-DB-RB-TE-LB) will show similar results to this study because fast twitch muscle fibers are essential to the basic actions of all skill positions. Overall, this study exemplifies the need for an emphasis on the vertical jump, broad jump, and flexibility tests for the defensive back position. Coaches can use this information to recruit future athletes with high scores in these areas. These results can also be used to complete depth charts at the conclusion of summer workouts and prior to the start of training camp.

REFERENCES

Allerheiligen, W. B. (1994). Stretching and warm-up. *Essentials of Strength Training and Conditioning,* , 289-313.

Calatayud, J., Borreani, S., Colado, J. C., Martin, F., Tella, V., & Andersen, L. L. (2015). Bench press and push-up at comparable levels of muscle activity results in similar strength gains. *The Journal of Strength & Conditioning Research, 29*(1), 246-253.

Christian, V. K., & Seymour, J. (1985). Specific power adaptations relative to strength-power training. *Nsca J, 6*, 32-34.

Ebben, W. P. (1998). A review of football fitness testing and evaluation. *Strength & Conditioning Journal, 20*(1), 42-49.

French, G., Grayson, C., Sanders, L., Williams, T., & Ward, M. (2016). A comparative analysis of the traditional sit-and-reach test and the RS smith sit-and-reach design. *The Corinthian, 17*(1), 5.

Hedrick, A. (1996). Strength and power training for football at the US air force academy. *Strength & Conditioning Journal, 18*(4), 20-30.

Hester, G. M., Conchola, E. C., Thiele, R. M., & DeFreitas, J. M. (2014). Power output during a high-volume power-oriented back squat protocol. *The Journal of Strength & Conditioning Research, 28*(10), 2801-2805.

Jovanovic, M., Sporis, G., Omrcen, D., & Fiorentini, F. (2011). Effects of speed, agility, quickness training method on power performance in elite soccer players. *The Journal of Strength & Conditioning Research, 25*(5), 1285-1292.

Miller, M. G., Herniman, J. J., Ricard, M. D., Cheatham, C. C., & Michael, T. J. (2006). The effects of a 6-week plyometric training program on agility. *Journal of Sports Science and Medicine, 5*(3), 459-465.

Nesser, T. W., Huxel, K. C., Tincher, J. L., & Okada, T. (2008). The relationship between core stability and performance in division I football players. *The Journal of Strength & Conditioning Research, 22*(6), 1750-1754.

Ostarello, J. Z. (2008). A visit to the shrines of the vertical jump and the 40 yard dash. *ISBS-Conference Proceedings Archive, , 1*(1)

Rampinini, E., Bishop, D., Marcora, S. M., Bravo, D. F., Sassi, R., & Impellizzeri, F. M. (2007). Validity of simple field tests as indicators of match-related physical performance in top -level professional soccer players. *International Journal of Sports Medicine, 28*(03), 228-235.

Sawyer, D. T., Ostarello, J. Z., Suess, E. A., & Dempsey, M. (2002). Relationship between football playing ability and selected performance measures. *The Journal of Strength & Conditioning Research, 16*(4), 611-616.

Shellock, F. G., & Prentice, W. E. (1985). Warming-up and stretching for improved physical performance and prevention of sports-related injuries. *Sports Medicine, 2*(4), 267-278.

Stone, M., Ramsey, M. W., Kinser, A. M., O'bryant, H. S., Ayers, C., & Sands, W. A. (2006). Stretching: Acute and chronic? the potential consequences. *Strength & Conditioning Jou rnal, 28*(6), 66-74.