THE CONTRIBUTION OF SELECTED VARIABLES TO COLLEGE FOOTBALL PERFORMANCE

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TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

CHAPTER I

INTRODUCTION

In the fall of 1970, this investigator completed a research study utilizing the Oklahoma State University varsity football team. Each subject was tested on eight different variables. These variables were as follows: forty yard dash, four-forty yard dash, finger reaction time, body reaction time, movement time, vertical jump, leg strength, and ACT composite score. It was the purpose of that study to determine to what extent each of these variables contributed to football performance as judged by game performance scores. It was found that the forty yard dash was the single best predictor with a correlation of .616. With a multiple correlation of .748, the forty yard dash and the ACT composite score yielded the highest correlation. By using these two variables, a significant correlation was reached. The remaining six variables contributed to make a total multiple correlation of .853.

After completion of the 1970 study, the investigator decided the results of the study warranted a more intensive investigation in this area. With the utilization of a greater number of subjects and variables included in the form of a future study, it was believed that possibilities existed for providing some interesting and helpful results to coaches. Further investigation, for example, might help coaches to see the importance of objective evaluation of their players, and it might provide them with information in regard to variables which are closely related

to football performance.

Not only was the investigator interested in a more intensive study because of the results of the 1970 study, but he was also interested in obtaining information which might be helpful in devising a method for screening athletes objectively rather than subjectively, as is presently the situation. It was hoped that this investigation would meet this need by providing a more objective means of determining what variables are most important in football performance. This would be helpful to the investigator because of his present position of head football coach at Southeastern State College. Therefore, because of interest stimulated by the 1970 study and because of interest in the coaching profession, this investigation was undertaken.

Purpose of Investigation

In the highly competitive sport of football, the task of assessing the variables which contribute most to an acceptable performance has proven to be very elusive and intangible. There has been much discussion and many opinions stated in regard to this problem, but there have been few studies conducted to ascertain the identity of these variables. These opinions raised questions as to what variables contributed to the making of a good football player, how much each variable contributed, and how accurately each variable could be measured. In realizing that there were a number of abilities involved which constitute a good game performance, this investigation addressed itself to the general problem of determining how much each of the variables selected for this study contributed to the game percentage score of members of the 1973 Southeastern State College football team.

Further questions dealt with in this investigation include the correlation between each of the variables. Which of the variables selected contribute the most to the game performance of a player, and which combination of variables will best predict the game performance of a player? Another subproblem was to determine whether the variables used for this study could be better predictors for the backs and line if they were treated as separate groups.

Ultimate Criterion

Of major importance to this investigation was the process of determining a valid criterion concerned with the selection of a good football player. The job of assessing a player and the task he must perform requires evaluative techniques that are both elusive and intangible. A coach, for example, may be well-qualified at judging the way a player performs a certain task. However, just because a player can successfully perform a football related task does not necessarily indicate how well he will perform in a game situation. For this investigation, a more valid, a more objective, and a more meaningful criterion was sought than might be obtained through a coach's evaluation of a football related task. Therefore, it was decided for this investigation that the performance of a football player during game conditions would be a better indicator of football ability.

The criterion which was used for this study was the game percentage score of each player. The game percentage score is defined as the total number of plays in which the subject is involved, minus the number of plays executed incorrectly. This sum is then divided by the total number of plays to obtain the game percentage score. This criterion was used

because the experienced coach has the ability to break down each play by means of a slow motion projector and to re-run each play until an accurate grade can be obtained.

By using the evaluative technique of reviewing game films, the investigator was able to remove himself from the stress of a game situation, thus improving his objectivity. Although there is subjective judgement involved in the investigator's grading of the film, his experience and knowledge in regard to techniques and assignments for the various positions should help to make his judgements more consistent and accurate. Barnette (1) stated that subjective criteria involves a judgement of performance usually made by somebody who is in a good position to rate the performance of each individual in the sample. The investigator of this study was in a "good position" to rate the subjects, and it was hoped that this position of the investigator would enhance the objectivity of his evaluation.

The "degree of uniformity with which various individuals score the same test" (2) is objectivity. The investigator assumed that another football coach should be able to review the same film and arrive at approximately the same score. It was hoped that the criterion measure used for this investigation could fulfill the requirements of this definition and a "degree of uniformity" in the grades of the subjects could be obtained if the film were graded by a number of coaches. Van Dalen (3) stated that probably the most valid technique for evaluating athletic achievement is available only to varsity coaches who film football and basketball games and spend hours observing and evaluating the play of each individual. Therefore, with the various statements above taken into consideration, it was believed that the game percentage score was the

best indicator of a good football player.

The reliability of the ultimate criterion should be strengthened by the experience of the rater, by the opportunity provided for observations, and by the degree of objectivity exhibited by the investigator. The reliability should have been strengthened or increased by consultation with other qualified judges in regard to the game performance scores of each subject.

Delimitations

The subjects utilized for this investigation were college-age males between the ages of 17 and 22. All were varsity team members at Southeastern State College.

Limitations

The small number of subjects used in this investigation may have been a limitation. It could be more beneficial to a coach in an investigation such as this if a large enough sample sufficient to categorize players by positions could be used, rather than having a few players representing all positions. By such an approach, a coach could begin to evaluate more specifically those skills involved for a particular position. Injury and sickness might also have caused some of the scores obtained on the skill variables to be lower than they might normally have been.

Hypotheses

The null hypothesis was utilized with regard to each of the variables tested in this investigation. Such hypotheses included the

following:

(1) The lateral jump is not significantly related to the game percentage score of a football player.

(2) The forty yard dash is not significantly related to the game percentage score of a football player.

(3) Bench steps are not significantly related to the game percentage score of a football player.

(4) Lateral movement is not significantly related to the game percentage score of a football player.

(5) The SCAT (Series II) score is not significantly related to the game percentage score of a football player.

(6) The vertical jump is not significantly related to the game percentage score of a football player.

(7) Body reaction time (vertical jump) is not significantly related to the game percentage score of a football player.

(8) Finger reaction time is not significantly related to the game percentage score of a football player.

(9) The twelve minute run is not significantly related to the game percentage score of a football player.

(10) The rope climb is not significantly related to the game percentage score of a football player.

(11) The Tuttle pulse ratio test is not significantly related to the game percentage score of a football player.

(12) Maximum breathing capacity is not significantly related to the game percentage score of a football player.

(13) No combination of the above variables would validly predict football performance.

Assumptions

Three assumptions were made in this investigation:

(1) The game percentage score was a valid indicator of a good football player.

(2) Each of the test variables selected was reliable, and, if each subject had been retested, the results would have been the same.

(3) All participants were equally and highly motivated.

Validity Factors

If a design is valid, it will probably yield a truthful result and one which can be interpreted as such. Care was taken by the investigator to insure internal and external validity in the following ways:

Internal Validity

Maturation processes were not a factor in this investigation since all of the subjects were tested on the variables within a short period of time.

Although most of the subjects during their off-season program had practiced some of the skills which were measured, they did not practice these skills as such during the regular football season. Therefore, the regular season did not serve as a learning experience for the subjects.

The tests were administered to each subject in precisely the same manner. The investigator did not have to use his subjective judgement on any of the skills exhibited by his subjects. The measuring instruments were consistent.

External Validity

External validity can be strengthened if the population to which the results will apply is thoroughly described. The population for this investigation was the 1973 Southeastern State College football team.

CHAPTER II

REVIEW OF LITERATURE

There has been a lack of scientific study directly related to successful football performance. Success in football is dependent upon a number of variables. Few studies have attempted to identify these variables or to show which variables contributed the most to a successful performance. Most of the related literature deals with the reaction and movement times or the vertical jump. Therefore, the review of the literature was broken down into these two areas, plus a section dealing with intellectual performances of athletes and a section dealing with prediction of athletic success and other related literature.

Movement and Reaction Time

Karpovich (4) defines reaction time as the time elapsing between the moment of application of a stimulus and the moment of response. Usually the term is applied to reactions requiring a conscious response.

In sports where movements of the athlete are conditioned by sounds or signals, by the movement of an opponent, or by movement of a ball, reaction time is of great importance. Athletes who have the ability to quickly react to a stimulus or respond to an opponent's movement have a definite advantage over slower-reacting men. When certain situations develop during the course of a contest, if a person has the ability to react and move, he can expect to be somewhat more successful than a

person who does not have this ability.

Reaction time will vary during one's life span. According to Morehouse and Miller (5), the shortest reaction times in both sexes occur between 21 and 30 years of age. DeVries (6) says there is fairly good agreement on the effects of age upon reaction time, fastest reactions being found in the college-age group and slower reactions in both younger and older groups.

Reaction time and movement time are faster when the stimulus is of an auditory nature. Much of the stimuli in football is of an auditory nature either in game-type conditions or in practice drills. Morehouse and Miller (5) simply state that the time which is required to react to a stimulus is dependent upon the nature of the stimulus. Response to a sound or a touch is quicker than a visual signal.

Therefore, it can be assumed for this investigation that, since the subjects were in the age group found to be the fastest at reaction time, and since all of the stimuli were of the auditory nature, the subjects probably reacted at their peek levels. Ricci (7), however, found that reaction time will vary within the same individual, depending upon such factors as the nature of the stimulus, the pattern of response, limb-dominance, age, fatigue level, shell and core temperatures, and ambrent temperature and humidity.

Published research on the relationship between speed of reaction time and speed of movement time does not appear to concur. Some researchers in this area had shown that these phenomena were unrelated while others had provided evidence of a positive significant relationship (8).

Miles (9) pointed out that it was first assumed if a man was quick

in one thing, such as moving the hand or finger, this score would be taken as representative of his speed in other motor performances. Now it is believed, as a result of careful testing of many individuals on a wide variety of measurements, that one score must not be trusted as an indication of all movements.

In a study involving the interrelationships of reaction time and speed of movement in different limbs, Lotter (10) used 105 college students as subjects. His study indicated a relatively high degree of specificity by limb and movement. He concluded that a person may be quick in reacting with an arm, but this does not necessarily mean that he will be quick in reacting with a leg.

Mendryk (11) compared reaction and movement times of subjects in age groups of 12, 22, and 48. He found that none of these groups produced significant correlations between reaction time and movement time.

In a study utilizing 60 male college students, Henry (12) investigated the relationship of reaction time and movement time. The task was such that the subject placed his hands on a treadle press key and, as a light stimulus flashed, the subject released the key and grabbed a tennis ball which was suspended on a string 12 inches above the key. The study revealed that the reaction and movement functions were independent and uncorrelated. The highest correlation obtained was that of .15.

In 1931, Miles (13), using 87 members of the Stanford University football squad as subjects, obtained seven measures of their charging times which he referred to as "reaction time." He reported no significant correlation between charging time and weight or height. The correlation of reaction time to playing skill measured by the opinion of the coaches in terms of efficiency was quite low.

Manolis (14) used 31 subjects, all of whom were members of the University of California football team. He tested them in order to obtain their response time in terms of executing a charge over a distance of 12 inches. Of the 31 subjects, 12 played sufficient time on offense to be rated by three judges on blocking performance in five games by use of movies. Two conclusions of significance were drawn from this study. First, there was no appreciable difference in speed of response in relation to position played. Secondly, consideration of the elements involved in successful blocking suggested that "timing" (such as a rhythmic cadence count) of the response, rather than speed of response, was the important factor.

Keller (15) tested a total of 755 men with 359 of them being classified as athletes. In this study, a comparison of movement times between the athletes and non-athletes was made. The study also attempted to ascertain if quickness of body movement was of value to athletic success. He found that athletes as a group scored significantly better than non-athletes in quickness of bodily movements. These results served as a basis for his suggestion that there was a definite trend and a real relationship between bodily movement and success in athletics—success being measured in terms of letters won, time played, or coaches' ratings. The study also made a comparison of movement times of the athletes according to their sport. From this comparison, it was concluded that the need for quickness is not the same for all sports. He suggested that persons not possessing good movement times would have a better chance to succeed if they concentrated in those sports which do not require reactions to rapidly changing movements of teammates or opponents. Included as sports in this category were such activities as gymnastics,

swimming, and wrestling.

Vertical jump reaction time was one of the measures utilized by T. K. Cureton (16) for an in-depth study of physical fitness measures of champion athletes. Included in his group of subjects were members of the 1948 U. S. men's swimming and diving team, U. S. track and field athletes, and the Danish gymnastics team. He suggested that there was a relationship between reaction time and body size with the shorter and lighter men, on the average, being faster than the taller and heavier men. He concluded that athletes in general have faster reaction times than nonathletes after comparing their times with a group of 80 non-athletes. He also concluded that reaction time was not dependent on muscular strength. These two conclusions were reaffirmed in this investigation as the shorter and lighter athletes did better on the body reaction time tests. The stronger players did not react quite so quickly as the smaller players.

Vertical Jump

In 1921, D. A. Sargent invented a "new test" of physical performance, the "Sargent Jump." The work of Sargent marked the beginning of one of the most widely used tests in physical education. The Sargent Jump and other forms of the vertical jump have been employed in numerous studies for the purposes of (a) classifying students; (b) predicting "athletic ability;" (c) measuring physical fitness; and (d) validating new tests and training programs in physical education (17).

Burley and Anderson (18) found a significant difference between the means of jump and reach test scores of athletes and nonathletes which indicated that power as measured by this test was closely associated

with athletic success. The study also revealed that the significance of the difference between the means of athletes in different sports was more closely associated with track, swimming, basketball, and baseball than with football.

In 1955, Burley and Anderson (18) conducted a study concerned with power as measured by the jump and reach and its relation to athletic performance and intelligence. The jump and reach test of power and the Henmon-Nelson Tests of Mental Ability were given to 1,013 high school boys. The relation between power measure and intelligence measure in the athletic group revealed a correlation of .037, which was too low to be predictive.

In 1961, Smith (19) tested the leg strength of 70 college men by means of a dynamometer. The leg was in a position designed to involve the power thrust of the major muscle groups used in the vertical jump. After performing a modified Sargent Jump that used no arm snap, the ratio of tested strength to body mass showed only a low and nonsignificant correlation with jumping performance. The results supported the hypothesis that strength exerted against a dynamometer involved a different neuromotor pattern than strength exerted by the muscles during a movement.

Huffman and Berger (20) used 50 college-age subjects randomly selected from students in a required physical education program. The purpose of the study was to determine whether relative (power relative to body weight) or absolute (actual) leg power, as measured by the modified leg power test devised by Gray, was a more accurate predictor of physical performance. They concluded that relative leg power as measured by the vertical jump was apparently a better predictor of cardiovascular

fitness and shoulder and arm strength endurance than was the leg power test.

Predicting Athletic Success

Brace (21) used 65 varsity football candidates at the University of Texas as subjects for part of a project in the investigation of the learning of gross bodily motor skills. He administered tests of achievement and obtained the average of three coaches' ratings in regard to the playing ability of the subjects. It was found that the fifty yard dash most closely correlated with the total scores on all tests.

In 1943, Di Giovanna (22) collected data on 102 athletes from Southern Illinois Normal University. The subjects were tested in three main categories: body structure, strength, and power (the vertical jump and the MacCurdy Physical Capacity Index). Within its limits, this investigation tended to substantiate the common claim that factors of body structure, muscular strength, and explosive power were associated with athletic success.

Thirty University of Iowa varsity baseball players were used as subjects for a study by Everett (23). The coach rated the players according to their playing ability; these ratings were used as the criteria against which the test results were correlated. From the results obtained in this study, it was determined that the Sargent Jump was the single best measure for selecting baseball talent.

Cowell and Ismail (24) collected data from 45 Purdue University football players to determine the players' football abilities. A revision of the Meyer's Football Playing Ability and Attitude Rating Scale was utilized. Nine variables were used in this test: condition,

aggressiveness, perserverance, team play, attitude toward coaching, ability to play position, blocking, tackling, and football knowledge. Five football coaches rated each team member on the nine variables. It was found that two out of the nine items were considered important in rating football ability. The two items were attitudes toward coaching and ability to play position. Attitudes toward coaching had a .656 correlation with the criterion score (coaches' ratings), while playing position had a correlation of .708.

A study by Mosteller (25), in 1969, used the Kansas State University freshman, sophomore, and junior football players. The players took part in an eight week off-season program in which the measuring of eight variables—chin-ups, push-ups, rope climbs, set-ups, stool jumps, vertical steps, lateral quickness, and the forty yard dash—was a regular part of the program. The results revealed that the variables contributing most to the multiple correlation coefficient for the linemen were lateral quickness and vertical steps. Lateral quickness and the rope climb variables contributed most toward the multiple correlation coefficient of the backs.

Pulse-ratio tests represent the ratio of the resting pulse to the pulse rate after exercise. According to Clarke (2), pulse-ratio tests conform remarkably well with the findings of physicians concerning the status of the cardiovascular system and may be used for determining the condition of the heart.

The Tuttle pulse-ratio test is one of the most popular pulse-ratio tests. In 1931, Tuttle (26) introduced a modified Hambley step-up test. This test is based on an observation that, for the same number of steps, a less fit person will have a relatively higher pulse rate during the

two-minute period of recovery immediately after exercise. The total number of pulse beats after exercise, divided by the resting pulse rate, is called the "pulse-ratio," and cardiac fitness is evaluated by determining the amount of exercise required to obtain a 2.5 pulse-ratio.

Tuttle found that the pulse-ratio test pointed out differences in a person's ability to perform certain gymnastic events such as the horizontal bar and the parallel bar. He also found that the pulse-ratio test pointed out differences in swimming ability. Because the test does point out differences in physical efficiency, Tuttle recommends its use by physical educators, both in the classroom and on the athletic field, as a means for identifying those in need of training programs.

The simplified Tuttle pulse-ratio test was developed by Tuttle and Dickinson (27) when they suggested the use of just one part of the original test, namely, stepping up and down 30 times per minute. Working with pulse-ratio, they found as reliable a ratio from a single performance of 30 steps per minute as they did from the exercises used to produce a 2.5 ratio. A correlation of .93 was obtained between the original test and one that consisted of stepping onto a 13-inch bench for one minute (30 times per minute). When the steps per minute were increased to 40, the correlation became .957.

Flanagan (28), in an earlier investigation, found a high correlation between the efficiency rating as measured by the pulse-ratio test and endurance in sprint running.

Intellectual Performance

There have been conflicting results in studies regarding intelligence and its relationship to physical performance. Most of these

studies have compared athletes to nonathletes. Hart (29) completed an investigation which consisted of 60 subjects from Springfield College. Their SAT scores were secured from the Admissions Office, their cumulative grade points from the Registrar, and their Physical Fitness Index scores were collected by the physical education staff. To eliminate the effect of the SAT results on scholastic success, partial correlation techniques were used to remove this effect on the relationship of physical fitness and academic grades. The investigator found that the correlations between SAT verbal scores and PFI, and between SAT mathematical scores and PFI, were not significant at the .05 level of confidence. However, when the effect of the verbal scores was removed, the relationship between success and physical fitness was significant beyond the .01 level of confidence. It was concluded that, although physical fitness was not a general predictor of academic success, it was high enough to be considered as a necessary factor for the improvement of academic index in the general education of the college student.

Slusher (30) conducted a study in which comparisons between high school athletes and nonathletes relative to personality profiles, as indicated by the Minnesota Multiphasic Personality Inventory, and intelligence, as measured by the Lorge-Thorndike Intelligence Test, were made. A total of 400 athletes were used for this study, 100 of which were football players. One hundred nonathletes were selected from individuals who had never attempted participation on a varsity team. It was found that intelligence was significantly lower for all athletic groups than for the nonathletic groups. Although the football group was significantly lower than the nonathletic group in intelligence, they exhibited a higher level of intelligence than any of the other athletic groups.

Studies by Biddulph (31), Snoddy and Shannon (32), and Milverton (33) are studies which also found that there was no intellectual difference between athletes and nonathletes.

In 1973, Davis and Berger (34) compared the academic achievement of college football and basketball athletes to determine whether differences were evident. A sample of 175 male students was randomly selected from approximately 3,000 non-varsity athletes at Texas Tech University. Thirty-four football and ten basketball varsity lettermen were randomly selected from a population of 95 football and 31 basketball lettermen. The statistical analysis involved predicting GPA of athletes from high school grades and SAT scores and comparing them to actual GPA. Since the prediction equation was based on nonathletes, the predicted GPA represented a score expected of athletes with the same predictor values as nonathletes. It was concluded that football and basketball athletes achieve as much academically in college as do nonathletes.

Cooper (35) attempted to review the empirical work concerning the relationship between athletics and various personality factors. While no intellectual differences were noted, a greater motivation to achieve was noted among athletes. In reviewing the literature on athletes' and nonathletes' intellectual performances, the general finding of several of these studies indicated no intellectual differences. Differences were noted in the area of intellectual functioning, however, when the measure was oriented towards achievement. The motivational factor here seemed to be the crucial difference, and athletes scored consistently higher than nonathletes on achievement-type verbal skill tasks. The investigator concluded that the data suggest the fascinating possibility that perhaps beyond a specific point in development, athletic participa-

tion interferes with aspects of intellectual functioning.

One reason for these conflicting results may be the nature of the population compared. The athletic group at the college level consists of a significant number who might not normally attend college if it were not for a scholarship. Consequently, these students may not achieve as much academically as other students. Comparing the athlete to the non-athlete at the college level on the basis of scholastic achievement may reflect differences due primarily to this selection process rather than to athletic prowess.

CHAPTER III

PROCEDURE

As many subjects were used for this investigation as was possible. Each member of the 1973 Southeastern State College football team that obtained enough playing time to receive an accurate game percentage score was used as a subject for this investigation. For this investigation, 30 players were deemed to have played sufficient time for an accurate game percentage score. The investigator graded the ten regular season football games for the 1973 season. The ten games were played against Southern Arkansas, Austin College, Northeastern State College, Southwestern State College, East Central State College, Langston University, Northwestern State College, Cameron State College, Central State University, and Panhandle State College.

The game percentage scores for each subject were calculated by taking the total number of plays in which the subject was involved, minus the number of plays executed incorrectly. A minus could be obtained by an athlete for mental mistakes, whereby the athlete failed to carry out the correct assignment or physical mistakes such as the use of improper techniques. The investigator consciously attempted to be consistent in his grading of the different positions. In some instances, the coach of the particular group being graded was consulted for his opinion in regard to a player's grade on a specific play. Objectivity of the game percentage scores was a priority of the investigator.

Consultation with the coach of a particular group was helpful in obtaining an objective score for each player.

The subjects were tested on the variables selected for this investigation at periodic intervals during the 1973 season. Twelve variables were selected for this investigation. Results of the scores for three of the variables were obtained out-of-doors with the subjects dressed in shorts and football cleats. These three variables were the forty yard dash, the twelve minute run, and lateral movement. Eight of the remaining nine tests were administered indoors with the subjects dressed in shorts and tennis shoes, the lone exception being the SCAT (Series II) which was administered to the subjects in a classroom after completion of the regular season. To limit the effect of external factors, such as wind, fatigue, and practice schedules from influencing the results of a subject's score, each subject was administered the selected variables on the same day.

Two major classifications were represented in the total number of subjects for comparison purposes. These classifications were the linemen, which included the center, offensive guards, offensive tackles, nose men, defensive tackles, defensive ends, and line backers. The line backers were included with the linemen because it was felt that the components of good line backer play were more closely aligned with skills possessed by linemen (Figure 1).

The other classification was that of the backs. This group included the quarterback, halfbacks, fullbacks, tight ends, wide receivers, corner backs, and safeties (Figure 2).

The data for the two groups were also treated together so that inferences could be made concerning both backs and linemen as a whole.

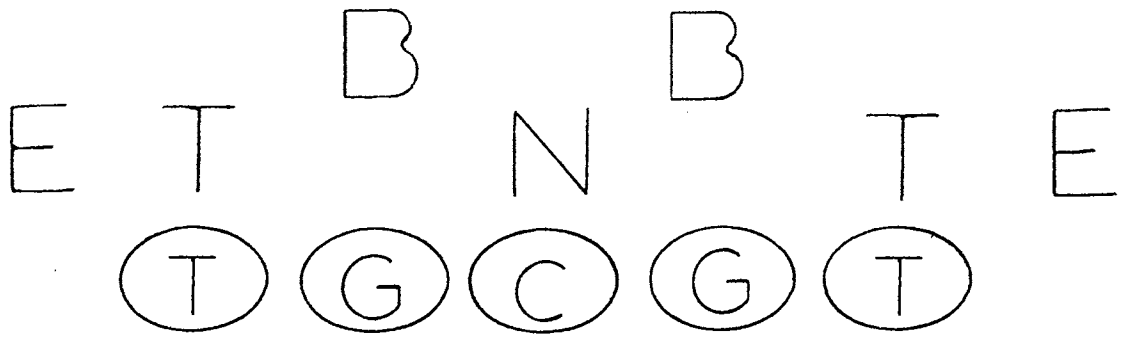

Figure 1. Positions Used in Analysis of Linemen Positions

E = Defensive Ends

T = Defensive Tackles

B = Linebackers

N = Nose Men

Ⓒ = Centers

Ⓖ = Guards

Ⓣ = Tackles

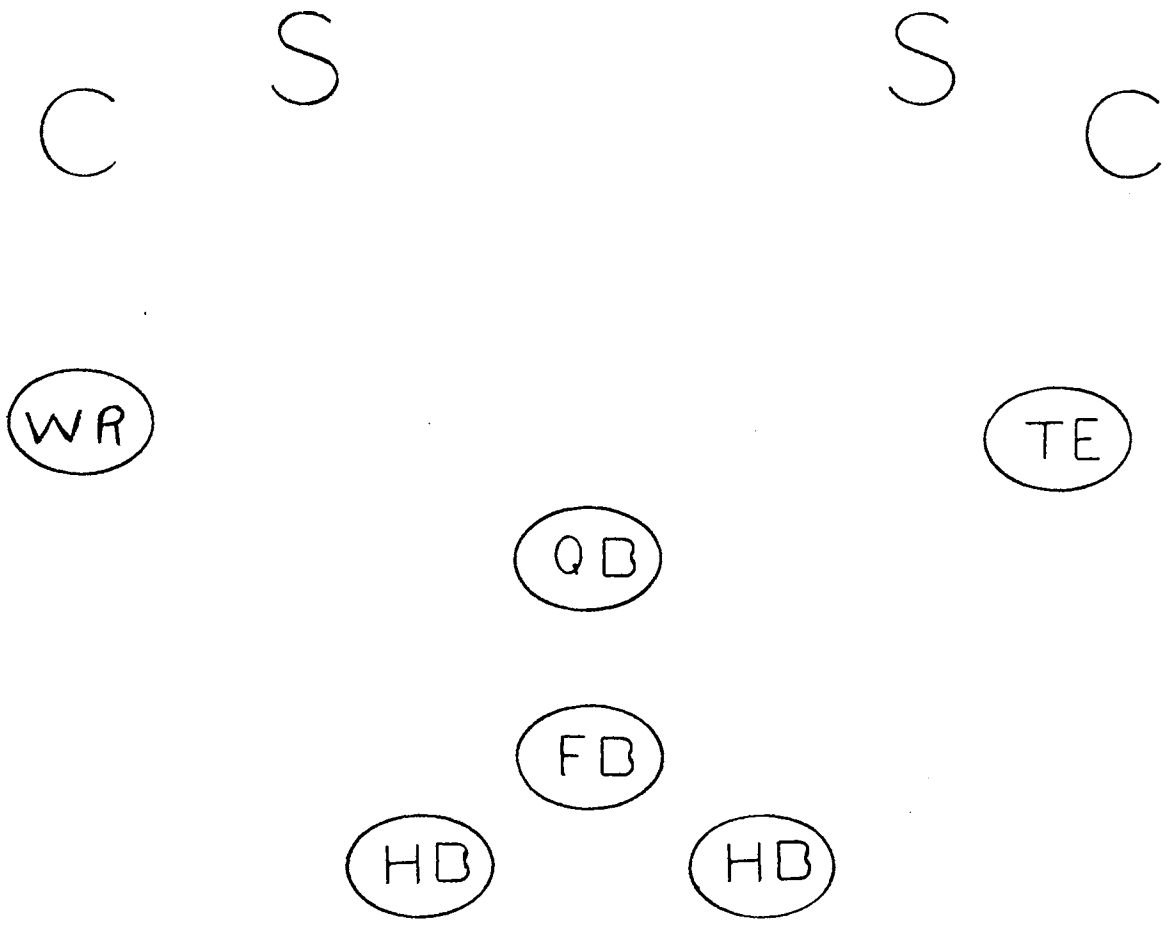

Figure 2. Positions Used in Analysis of Backfield Positions

C = Cornerbacks
S = Safeties
WR = Wide Receivers
TE = Tight Ends
QB = Quarterbacks
FB = Fullbacks
HB = Halfbacks

Of the 30 players included in this study, 16 were backs and 14 were linemen.

Measuring Devices

The Dekan Athletic Performance Analyzer was utilized to record times for the forty yard dash, body reaction time (vertical jump), and finger reaction time. This device is capable of recording times to the nearest one-hundredth of a second. The forty yard dash utilized a foot pedal which was connected to the analyzer. When the pedal was depressed, it activated the timer. As the foot left the pedal, the clock started. A switch mat device placed on the floor was utilized to activate the timer during the vertical jump. The clock started as soon as the subject's feet lost contact with the mat. For the finger reaction time, a small cylindrical device was utilized. At the end of the device was a small button which was depressed by the thumb or forefinger of the subject to stop the timer after it was started by an auditory stimulus. All of these special devices for timing the various tests were connected by wires to the Dekan Athletic Performance Analyzer unit.

A Bell and Howell Cassette Tape Player was used for the Tuttle pulse-ratio test. The investigator recorded the instructions for this test plus a segment containing a 30 step-per-minute cadence for the subject to follow during the test.

The CD4 Dry Gas Meter was used for the maximum breathing capacity test. The CD4 recorded on a meter the amount of air expelled by the subject in liters. A Collins one-way valve, mouthpiece, and nose clip were also used to ensure maximum results.

A standard Hanhart stopwatch which recorded to the nearest tenth of

a second was used for the lateral jump, bench step, lateral movement, rope climb, and twelve minute run tests.

A Kodak Analyst Projector was used to obtain the game percentage scores of each subject. The projector had the capability of running the rilm in slow motion and of being reversed so that each play could be looked at until a grade for each subject on every play could be obtained.

Selected Variables

The variables selected for this investigation and the test procedures were as follows.

1. Lateral Jumps

In this test a balance beam was set up so that the top of it was 13 inches from the floor. The subject was instructed to begin with his feet parallel to the beam. On the stimulus to start, the subject saw how many times he could jump over the beam in a 30 second time span. This variable was utilized in a study by Mosteller (25) in 1969 at Kansas State University. The present investigator had seen this variable used by many of the colleges and high schools across the nation. It was also the opinion of the investigator that the ability of a player to move his feet quickly was a good predictor of football success, particularly for offensive linemen.

2. Bench Steps

A bench 18 inches in height was utilized for this test. On the command to start, each subject stepped onto the bench with either foot he chose. His other foot was lifted to the bench so that weight was supported on each foot. To step down off the bench, the same foot which

was first lifted to the bench was placed on the floor. The other foot followed so that the subject was in the same position as for the start of the test. This procedure was followed for 30 seconds, and the number of steps the subject obtained was recorded as the subject's score.

Several tests, such as the Tuttle pulse-ratio test and the Harvard step test, have utilized bench steps as a means of inducing work loads on subjects. Although pulse rates are taken and other calculations are used to determine the "fitness" of each subject, it was of interest to the investigator to see if the number of steps a person could complete in a specified time would be a good predictor of football performance. This test was also included because Mosteller's (25) study revealed that bench steps was one of the variables that contributed most to the multiple correlation coefficient for linemen.

3. Tuttle Pulse-Ratio Test

Tuttle's pulse-ratio is interpreted as the ratio of the resting pulse rate to the rate after exercise (stepping up and down on a 13 inch bench). This ratio was computed by dividing the total number of pulse beats for two minutes after a standard exercise by the number of resting pulse beats counted for one minute. The cardiovascular efficiency of a person is determined by the amount of exercise required to obtain a 2.5 pulse-ratio (26).

Tuttle and Dickinson (27) found that the ratio from a single stepping performance of 30 to 40 steps per minute yielded high correlations. Therefore, this simplified Tuttle pulse-ratio test using 30 steps per minute was used for this test.

The fact has been well demonstrated that the physical condition of

an individual has a definite effect on his athletic performances. An individual who is physically conditioned will be less affected by a given amount of exercise than an individual in poor condition. The ability of the individual's heart rate to return to normal after cessation of exercise, or his ability to recover from exercise, would appear to be a definite factor in achieving athletic success. It was on the basis of these factors that this test was included in the investigation.

4. Maximal Breathing Capacity Test

Maximum breathing capacity is defined as the maximum volume of air that can be moved in and out of the lungs per unit time (36). Physical fitness research people have tried to find a relationship between the maximum breathing capacity test results and some characteristics of athletic ability and physical fitness. Although positive results have not always been obtained, with more research its results may be found to be more closely related to specific levels of fitness. It was of interest to the investigator to determine if the maximum breathing capacity of an individual would be a good predictor of football performance.

The CD4 Dry Gas Meter was used to obtain the subject's maximum breathing capacity. The test consisted of seeing how much air each subject could move through his lungs in a given time period. The time basis is standardized at one minute. However, since a person cannot hyperventilate (as the test requires) continuously for this length of time, a 15 second reading was taken with the results multiplied by four to get each subject's maximum breathing capacity for one minute. Care was taken to see that the mouthpiece and noseclip were securely fitted. The subject was encouraged to breathe deeply and rapidly, recognizing that

there must be a compromise between rate and depth of breathing to get the best results. Each subject was given two trials. The subject's predicted maximum breathing capacity was subtracted from the actual maximum breathing capacity, and this residual, or difference, was used as the subject's score for this test. By utilizing the residual, body size was eliminated as a factor. The subject's best score of the two trials was used for this investigation.

5. Forty Yard Dash

The subject was required to run four forty yard dashes, with the time being recorded to the nearest one hundredth of a second. The times were taken by means of the Dekan Performance Analyzer. Each subject started from a three point stance. The test was set up so that, when the subject's foot left the foot pedal, the clock would start. A peg with a string attached to it was inserted into the analyzer. The string was stretched across the finish line at a distance 40 yards from the foot pedal. As the subject crossed the finish line, his body struck the string and pulled the peg from the analyzer, thus stopping the clock. The best of the four timed trials was utilized for this investigation.

Brace (21) found that the fifty yard dash was most closely correlated to playing ability, and this investigator found that the forty yard dash was the single best predictor of a good football player in an earlier investigation (37).

6. Lateral Movement

This test was administered on a football field where two assistants stood on yardlines five yards apart. The subject stood between these

assistants with one foot alongside and touching the foot of one of these assistants. On the starting command, the subject, keeping his shoulders perpendicular to the yardlines, moved laterally until he touched the knee of the other assistant. He returned to the starting point where he touched the knee of the assistant. He repeated this procedure until he returned to the starting point for the fourth time. His time was obtained at this point and recorded to the nearest tenth of a second.

In the opinion of the investigator, the ability of a football player to move laterally is highly desirable. The ability of a defensive player to move laterally down the line of scrimmage in order to make tackles, and the ability of offensive linemen to move laterally to "pick up" various defensive stunts is invaluable. Lateral quickness was shown to be a good predictor of football performance by Mosteller (25) as he used a test similar to the test described above.

7. SCAT (Series II)

The School and College Ability Test was administered to each subject. This test is designed to provide estimates of basic verbal and mathematical ability. It is also used to predict success in related activities. The test was administered to the subjects in two separate 20 minute time periods. The verbal score was based upon the number of correct responses to 50 quantitative comparison items in 20 minutes. The raw scores were converted into percentile scores based on individual score norms for grade twelve. Each subject's percentile rank was recorded and used for this investigation. The SCAT was developed by the Educational Testing Service. Correlations between corresponding parts of the SCAT and SAT were found to be .83 and .86 for the verbal

and mathematical sections, respectively.

8. Body Reaction Time (Vertical Jump)

The Dekan Athletic Performance Analyzer was used for this test. This test was utilized to determine how fast the subject could move his entire body off the ground (switch mat). An audible stimulus for this test was utilized, and the investigator randomly lengthened or shortened the time between the command, "ready," and the time the stimulus occurred. This was to rule out the possibility of anticipation. After the subject responded to the stimulus, (the clock stopped as soon as the subject's feet left the mat), the time was recorded to the nearest hundredth of a second. Three practice trials were allowed with five trials for record. Keller (15) found that bodily movement had a real relationship to athletic success. This study, and other similar studies, support the investigator's opinion that the ability to move one's body is a variable which can contribute significantly to football performance.

9. Finger Reaction Time

An audible stimulus was used for this test. The subject held the contact switch in his hand, and, using his thumb or forefinger, depressed the switch as soon as the stimulus occurred. The subject's reaction time was recorded to the nearest one hundredth of a second. Each subject was given five practice trials and ten trials for record. Westerlund and Tuttle (38) used 22 college track men in a study and found the relation of reaction time to running the 75 yard dash resulted in a positive correlation of .86.

10. Rope Climb

Each subject was required to climb a rope and touch a point on the rope 20 feet from the floor. The subject was allowed to use his hands and feet during the climb. His time was taken with a standard stop watch and recorded to the nearest tenth of a second. Each subject was given two trials, the best time to be utilized for this investigation.

The rope climb was included as a variable to determine if arm, shoulder, and back strength contribute significantly to football performance. The rope climb also required a great deal of co-ordination, a variable which football coaches feel is of great importance to football performance. Mosteller's (25) study revealed that the rope climb was a significant contributor to the multiple correlation coefficient of backs.

11. Twelve Minute Run

A regulation quarter mile track was used to see how far each subject could run during a twelve minute period. On the command to start each subject ran until he was given the command to stop. The distance which each subject ran during the twelve minute period was then recorded to the nearest quarter of a lap. This test had been recommended as a test of maximum oxygen intake. It was also given as a measure of the subject's endurance fitness. Endurance is essential to good athletic performances because it involves both the muscular and cardiorespiratory systems. Conditioning of the muscular and cardiorespiratory system reduces the amount of energy the body must exert to perform a specific task and delays the onset of fatigue. It was of interest to the investigator to determine how significantly endurance fitness contributed to

the multiple correlation coefficient of football performance.

12. Vertical Jump

Each subject was given three jumps on this test, with the best jump being used for this study. The subjects were asked to stand with their toes to the wall and to reach as high as possible with one hand so that the distance from the floor to the tip of his finger could be measured. The subjects were then asked to jump and reach as high as possible, touching the side of a basketball backboard which had been labeled with the correct height as measured from the floor. The bottom marking was located nine feet from the floor; the top, ten feet, six inches. The investigator stationed himself upon a ladder so that he could observe closer the touching of the side of the backboard. The subject's standing reach was subtracted from his jumping reach and this difference was recorded as the indication of his jumping ability.

The vertical jump has long been associated with athletic achievement; therefore, the vertical jump was included in this investigation.

Statistical Treatment

The statistical treatment utilized in treating the data collected for this investigation was a step-wise multiple regression. The step-wise multiple regression was used to determine the weight of the variables selected for investigation. The step-wise regression computes a sequence of multiple linear regression equations in a step-wise manner. At each step, one variable was added to the regression equation. In this manner, it was possible to see how much each variable contributed to the game percentage score of the players used in this investigation.

The data for the backs and the data for the linemen were treated separately to determine if a variable could be significant to one group and not to the other group. The skills required to play as a back or a lineman appear to be different, and valuable results might go undetected if the data were treated as a whole. However, the data were also treated together to determine if a variable was important to both backs and linemen.

For this investigation, the .01 level was set as the level of significance for each individual variable. A multiple correlation of .85 was set as the relationship required for acceptance as a significant predictor of football performance.

Justification

There are many intangible variables which contribute to the successful performances of a football player. However, there are some that can be identified. It would be very helpful to a coach if he knew just how much each of these variables contributed to the game percentage score of his players. There was also a great need for this type of investigation for the following reasons: (1) It could give the coach an objective method of evaluating his players; (2) It could determine what variables are most important for successful performance, thus allowing the coach to budget his practice time accordingly; (3) It could be used to predict what an athlete's game percentage score should be according to his scores on the selected variables; (4) The most important skill variables might be used as a screening device for prospective players; (5) It could be used as a motivational factor for the players during their off-season program; (6) It might be used to determine how valid

an indicator the estimated game percentage score could be in the determination of a good football player.

CHAPTER IV

RESULTS AND DISCUSSION

This chapter includes a summary and discussion of the data collected from the 12 variables and game percentage scores of 30 members of the 1973 Southeastern State College football team. The researcher considers the results to be consistent from the standpoint of each subject's "all out" effort on the test items. The immediate visibility of objective results motivated intense competition. Many questions were asked by the subjects concerning how much "weight" the coaches were going to give the results and how other subjects had fared on a particular test item. The players took the measurement seriously and apparently considered it indicative of ability.

Table I reveals the means of the three different groups utilized for this investigation. The backs scored highest on 10 of the 13 variables tested. The line group scored highest on the lateral jump, bench steps, and reaction time. The backs scored higher than the line on the forty yard dash, SCAT, rope climb, and game percentage score. The line performed better on the tests which required quick movement of the feet. This might be explained by the fact that there are many drills designed for linemen which emphasize quick, choppy movements of the feet.

The means scores can be deceiving when they are considered as a separate entity. Comparisons between the back and line groups, solely in regard to their means, are insufficient to draw quantitative

TABLE I

MEAN SCORES FOR THIRTEEN VARIABLES
(BACKS, LINEMEN, AND TOTAL)

Variable	Backs	*SD	Linemen	*SD	Total	*SD
1	56.37	5.264	57.00	5.751	56.66	5.409
2	36.25	3.785	36.78	2.778	36.50	3.308
3	2.456	.2510	2.366	.4728	2.414	.3672
4	161.6	26.83	157.9	30.18	159.9	28.39
5	4.876	.1353	5.215	.1738	5.031	.2361
6	10.40	.4287	10.83	.3931	10.59	.4579
7	53.25	11.77	40.28	13.75	47.20	14.13
8	.2011	.0493	.2187	.0460	.2093	.0506
9	.1281	.0183	.1222	.0111	.1254	.0151
10	10.09	1.265	13.05	2.466	11.47	2.411
11	6.765	.4130	6.375	.4874	6.583	.4801
12	25.81	2.786	23.42	2.927	24.70	3.052
13	73.70	7.614	67.60	8.907	70.85	8.668

1. Lateral Jump (number of jumps/30 seconds)
2. Bench Steps (number of steps/30 seconds)
3. Tuttle Pulse Ratio Test (simplified, 30 steps/minute)
4. Maximum Breathing Capacity (liters/minute)
5. Forty Yard Dash (seconds)
6. Lateral Movement (seconds)
7. School and College Ability Test (Series II) (percentile rank)
8. Body Reaction Time (seconds)
9. Reaction Time (seconds)
10. Rope Climb (seconds)
11. Twelve Minute Run (number of laps completed)
12. Vertical Jump (inches)
13. Game Percentage Score (percentage)

*Standard Deviation

NOTE: Variable numbers in subsequent tables correspond to the numbers in the above table.

conclusions. When the raw scores of these variables were placed into the step-wise multiple regression equation, many more conclusions became evident which could not be drawn from the means alone.

From the data collected on the subjects, a product-moment correlation matrix of the game percentage scores and the 12 measured variables was prepared. The determination of the contribution of each of the variables tested and their relationship to the game percentage scores was one of the primary purposes of this investigation. From the step-wise multiple regression equation, the 12 variables were selected in the order of their contribution to the game percentage scores. The amount of weight each variable contributed was indicated by the multiple correlation coefficient. The simple correlation results and the multiple correlation results will be presented from the standpoint of each individual variable. Each variable will be discussed in regard to its relationship with the backs, the line, and the total data of these two groups combined.

Results Related to Backs

(Tables II and III)

Variable #1 (Lateral Jump)

It was the opinion of the investigator that the ability of a football player to move laterally with quickness was an asset to be highly desired if the player expected to enjoy a reasonable amount of success. This belief was not confirmed by the results of this study in regard to the backs. The correlation of the lateral jump to the game percentage score was only .04. Quick lateral movements of a few steps are not as important to the backfield positions as they are to the line positions.

TABLE II

CORRELATION MATRIX FOR BACKS

Correlation of .456 Needed for Significance at .01

Variable Number	1	2	3	4	5	6	7	8	9	10	11	12	13
1	1.000	0.604	-0.256	0.457	0.177	0.645	0.260	0.268	0.152	0.099	0.633	-0.099	0.044
2		1.000	-0.025	0.429	0.149	0.499	0.094	0.069	0.223	0.066	0.232	-0.204	0.010
3			1.000	-0.626	-0.036	0.048	-0.592	0.026	0.387	0.175	-0.325	0.143	-0.195
4				1.000	0.083	0.169	0.119	-0.166	-0.368	0.014	0.451	-0.417	0.007
5					1.000	0.446	-0.277	0.087	-0.127	0.375	0.339	0.564	0.271
6						1.000	0.097	0.317	0.314	0.074	0.479	0.220	0.330
7							1.000	0.316	-0.073	0.239	0.095	-0.248	0.278
8								1.000	0.483	0.043	0.019	-0.068	0.207
9									1.000	-0.081	-0.182	-0.139	-0.172
10										1.000	0.016	0.099	0.300
11											1.000	0.119	0.278
12												1.000	0.308
13													1.000

Although it is an asset in any sport for an athlete to be able to move his feet quickly, which this test requires, the offensive backfield positions are concerned more with powerful forward thrusts into the line. The defensive backfield is concerned more with retreating backward to cover passes and moving forward to make tackles on ball carriers breaking through the line of scrimmage. Therefore, the low relationship of the lateral jump to the game percentage score is not too surprising. However, it should be noted (Table III) that the lateral jump was the fourth leading contributor to the multiple correlation, raising the correlation from .5088 to .5794. The correlation was significant at the .05 level of significance.

TABLE III

MULTIPLE CORRELATION COEFFICIENT WITH GAME PERCENTAGE SCORES (BACKS)

Selection	Variable	Multiple Correlation
1	6	.3302
2	9	.4400
3	8	.5088
4	1	.5794
5	10	*.6280
6	11	*.6629
7	5	*.6890
8	12	*.7090
9	2	*.7236
10	3	*.7342
11	4	*.7358
12	7	*.7449

*Denotes this combination of variables to be significant at the .01 level.

The lateral jump correlated most highly with the lateral movement and twelve minute run variables with correlations of .64 and .63, respectively. With 30 subjects and 29 degrees of freedom, both were significant at the .01 level of confidence. Both of the correlations seem plausible, particularly the correlation with lateral movement. The vertical jump and twelve minute run both involve the movement of the feet; this could explain the relationship of these two variables.

Variable #1 (Bench Steps)

The bench steps had a correlation of .01 with the game percentage score. This correlation was in direct contrast with the bench steps correlation to the game percentage score for linemen since it was the number one predictor of the game percentage for this group. This difference might be partially explained by the fact that in grading the film the ability or inability of a back to move his feet did not affect his score as much as that for a lineman. A lineman's score was determined to a large extent by whether he had quick enough feet to adjust to a defensive stunt or to react quickly enough to the block of an offensive lineman. In contrast, a back could not be awarded more towards a good game percentage score by exhibiting a quick movement of the feet which enables him to avoid a tackle than if he had been tackled at the line of scrimmage after running the correct play at the correct hole. The low correlation of the bench steps to the game percentage score might, therefore, be attributed, at least partially, to the grading technique. In the opinion of the investigator, the ability of a back to perform these quick movements, which enable him to break free, is one of the differences in a great and a good back. This investigator recommends

future studies in which a grading system might be devised to award a player two pluses for a play in which exceptional skill is exhibited, such as a goof "move" by a back. Bench steps was the ninth contributor to the multiple correlation. Combined with the other variables to that point, a correlation of .7236 was reached.

The bench steps correlated .60 with the lateral jump and .49 with the lateral movement variable, both of which were significant at the .01 level. These correlations might be explained by the fact that they all involve quick movements of the feet.

Variable #3 (Tuttle Pulse-Ratio)

An athlete's ability to recover after exercise, as measured by the Tuttle pulse-ratio, did not appear to be a factor of major importance for backs in this investigation. Ramsey and others (39) conducted a study in which the relationship between brief rest intervals and physiological recovery during intensive physical activity was investigated. They found that brief intervals, as short as 40 to 60 seconds in duration, provided opportunity for physiological recovery in terms of significant decreases in heart rate response. In football, the time lapse from when the ball is blown dead until the next play is initiated might be sufficient for the recovery of the heart rate. These rest periods might be sufficient to negate the effect of recovery time in regard to football performance. Heart rate has also been shown to give quicker response to emotional involvement than do other measures of physiological cost. There are many variables which affect heart rate. Therefore, when heart rates are used, care should be taken by investigators when drawing conclusions or making predictions.

According to the pulse-ratio scales provided by Tuttle, the back and total groups achieved ratios between 2.4 and 2.5, ranking them in the average group. The line group, with a mean ratio of 2.366, ranked in the above average group. Cureton (16) tested a group of athletes, and found their mean ratio to be 2.35. From these two sources, it is evident that the subjects used for this investigation were in the average category for this test variable.

The correlation of the Tuttle pulse-ratio to the game percentage score was -.19. Inverse relationships were also found between the Tuttle pulse-ratio and maximum breathing capacity (-.62) and the SCAT (-.59). The top positive correlation was reaction time with a correlation of .38. The Tuttle pulse-ratio was the tenth variable entered in the multiple correlation equation.

Variable #4 (Maximum Breathing Capacity)

Like the Tuttle pulse-ratio, maximum breathing capacity was also a poor predictor of the game performance score for backs with a correlation of .007. Both of these variables are non-football related tasks which might explain their low individual significance to the game performance score and their overall contribution to the multiple correlation. The results in regard to this group concur with other research in this area in finding no relationship between maximum breathing test results and characteristics of athletic ability. Although body size was eliminated as a factor in the test results by utilizing the residual between the subject's actual maximum breathing capacity and predicted maximum breathing capacity, the larger subjects obtained better scores on this test. The black athletes did very poorly on this test. Numerous studies have

shown that blacks have lower respiratory capacities than whites, particularly their vital capacities. Since vital capacity is closely related to maximum breathing capacity, and since there were more black players in the back's group, the maximum breathing capacities lack of significance in this group might be explained. A future study in this area might yield some interesting and useful results.

Another explanation might be the fact that backs and ends can perform their tasks of running short distances, at times uninhibited, while not having to displace any air into and out of the lungs. The ability to move air into and out of the lungs may not be as big a factor since many of their tasks can be performed while holding their breath.

Maximum breathing capacity correlated -.62 with the Tuttle pulse-ratio and .457 with the lateral jump. There was also a correlation of .451 with the twelve minute run. This relationship can probably be explained by the fact that both variables possessed close relationships to the respiratory system.

Variable #5 (Forty Yard Dash)

The forty yard dash had a correlation of .27 with the criterion measure. However, it was the seventh variable entered into the multiple correlation equation and combined with the other six variables the resulting .6890 correlation was significant at the .01 level. The two most significant correlations were with the vertical jump and lateral movement. These correlations were .56 and .44, respectively, each of which were significant at the .01 level. It seems plausible that the vertical jump should be highly related to the forty yard dash because both variables are dependent upon explosive power from the hamstring and gluteus

muscle groups. The lateral movement correlation might be explained again by the ability to move one's feet with explosive power in a lateral direction similar to the forward movement exhibited in the forty yard dash. It would seem to behoove coaches to develop the muscle groups which would allow the athlete to develop the explosive power needed for improvement in the area of speed development.

The investigator was surprised at the results obtained in regard to this variable. As cited earlier, the forty yard dash was the single best predictor of the game percentage score in a previous study. The previous study was conducted at Oklahoma State University. It is logical to assume that major college football players will possess more overall speed than players who attend small colleges such as the one used for this investigation. Therefore, the quality of the athlete making up the population, along with the type of competition being played, might be the significant difference here rather than the seemingly insignificance of the variable itself. The investigator can think of many instances during his coaching career where individuals who did not possess adequate speed were still some of the better performers on the team. This was certainly the situation with regard to the subjects used for this investigation. The ability of these individuals to react and move their feet seemed to take precedence over speed. However, the investigator believes there is no substitute for speed. A good athlete can become an outstanding athlete with the addition of speed. Speed is one variable which has physiological limits and one which is difficult to improve upon. Probably the major difference in major college and small college football players is the fact that major college players, aside from having the other abilities previously mentioned, also have speed. This

sets them apart from the average athlete.

Variable #6 (Lateral Movement)

Lateral movement had a correlation of .33 with the criterion measure. Although it was not significant at the .01 level of confidence, lateral movement had the highest correlation with the game percentage score, and, thus, was the variable which contributed most to the multiple correlation. The lateral jump, with a correlation of .64, the bench steps, with a correlation of .49, and the twelve minute run, with a correlation of .47, were the highest correlations to the lateral movement variable. All of these variables were significant at the .01 level. These variables deal with movement of the feet; therefore, it is no surprise that they should be highly correlated with lateral movement.

Lateral movement is a very important asset for a defensive back to possess. The ability to move laterally and to adjust to the change of course taken by a receiver, or to move laterally on an interception course with the flight of the ball, are invaluable assets to defensive backs. Defensive backs perform many drills designed to improve their lateral quickness. These drills probably contributed greatly to the lateral movement variable being the top predictor of the game percentage score for backs. Offensive backs and ends practicing their pass cuts inevitable help their lateral quickness, too. The ability of an offensive back or end to lower his center of gravity and to make sharp decisive changes in direction are definite assets which help these individuals become better players. The lateral movement variable, in the opinion of the investigator, is the one variable most likely to have been influenced by the effect of practice. Further investigation

should be completed before any concrete statements regarding lateral movement and its predictability to football achievement can be made.

Variable #7 (School and College Ability Test)

There are conflicting reports in regard to intellectual functioning and its relation to physical performance. Most of the literature concurs that there is no significant difference between athletes and non-athletes in intellectual and academic achievement. The results of this investigation definitely agree with these findings. The correlation of the SCAT to the game percentage score was .27. However, it was the last variable entered into the multiple correlation equation and only contributed .009 to the multiple correlation of the game percentage score. These results are in direct conflict with the investigator's previous study where the intelligence variable was found to be the second most accurate predictor of the game percentage score. However, these conflicting results could very well be centered around the subjects involved in the two studies. The intelligence of the subjects in the previous study at Oklahoma State was much superior to the subjects used in this study. There are basically two reasons for this situation: 1. The entrance requirements are higher at Oklahoma State; and 2. There is basically one reason that small colleges have some outstanding athletes, the reason being that the athlete does not have the grades to gain admittance to a major college. Therefore, we are dealing with an entirely different athlete in this investigation. This reasoning is only speculation on the part of the investigator. Lacking are investigations of what seems unique to athletes, namely, their motor skills, in relation to intellectual functioning. An important question would be how physical

activity itself is related to intellectual performance.

After reviewing the results of this investigation, the possibility exists that the selection of the SCAT as an intelligence measure might have been an error in judgement on the part of the investigator. The use of a measure of creativity, or a measure of one's ability to learn, may have been a better predictor.

Variable #8 (Body Reaction Time)

Body reaction time was the third leading contributor to the multiple correlation for backs. When body reaction time was added to the top two predictors, a multiple correlation of .5088 was obtained. This correlation was not significant at the .01 level. An intercorrelation of .20 was obtained with the game percentage score.

The body reaction time test is essentially the same as the reaction time test, the exception being that body reaction time measures the ability to move the whole body as a unit in response to a stimulus rather than just a part of the body such as reaction time employs. Since the mass is greater, body reaction times are slower than simple reaction times. Table I reveals the means for body reaction time to be .2011, .2187, and .2093 for the back, line, and total groups, respectively. The times obtained by this investigator in the previous study utilizing the Oklahoma State University varsity team members produced correlations of .225, .235, and .229 for the back, line, and total groups. In comparing the times of this investigation to the percentile score tables prepared by Cureton, a percentile rank of 96 was obtained by the back group, and a percentile rank of 93 was obtained by the line group. The norms prepared by Cureton also placed the back group in the

superior category. Varsity track members at Oklahoma State had a body reaction time mean of .267 and men physical education majors had a mean score of .280. In comparing the times obtained in this investigation with the previous study and norms mentioned above, it would appear that the body reaction times were very good for the subjects in the more recent study.

The ability of a football player to hear or see a stimulus and respond by moving his entire body appears to be a valuable asset to physical performance. The ability to respond to a stimulus and to move the entire body from a football stance as quickly as possible is essential if backs are to perform at peak efficiency.

Variable #9 (Reaction Time)

Reaction time and its relationship to athletic performance has been the topic of many investigations. The results of these studies do not always concur, but few investigators challenge the value of good reaction times to various athletic skills. In this investigation, for the back group, reaction time was the second leading predictor of the game percentage score. Combined with lateral movement, a multiple correlation of .44 was obtained, making the combination of these two variables significant at the .05 level. The correlation matrix (Table II) revealed intercorrelations of .64 with the lateral movement and .63 with the twelve minute run, each of which was significant at the .01 level.

Table I reveals the means for the back, line, and total groups to be .1281, .1222, and .1254, respectively. In comparing these times with the norms established from Oklahoma State University physical education majors, it was found that the subjects from this investigation

obtained considerably faster times. The mean time of the majors group was .19. Ferguson (40) utilizing 60 male college students as subjects obtained a mean reaction time of .15. This group was composed of some nonathletes. Therefore, the results of this study make it more difficult to draw comparisons since athletes are known to have quicker reaction times than nonathletes. However, in comparing reaction times from this investigator's previous study utilizing varsity members of the Oklahoma State University football team, to reaction times from this present study, a slightly better performance was exhibited by the subjects in the most recent investigation. The mean times from the previous study were .129 for backs, .134 for the line, and .131 for the total. From the two studies and norms just cited, it would seem to indicate that the subjects used for this investigation exhibited very good reaction times.

Reaction times are inborn and have definite physiological limits. A person either possesses this trait or he does not since practice has a minimal effect on improving reaction times. The ability to react to a stimulus appears to be an asset to a football player. It would appear that the better athletes possess this quality and can react to stimuli in the shortest possible time. This condition might partially explain reaction times contribution to the game percentage score for backs.

Variable #10 (Rope Climb)

For the backfield group, the rope climb had the third highest simple correlation with the game percentage score, producing a correlation of .30. The rope climb was the fifth variable entered into the multiple correlation equation and combined with the other variables

helped to produce a .628 relationship. This correlation was significant at the .01 level. The rope climb correlated highest with the forty yard dash, obtaining a correlation of .37.

The rope climb was the only variable tested which required a certain amount of strength to perform successfully. Shoulder, arm, wrist, and grip strength are involved in the successful completion of the rope climb. Although strength is an asset in any sport, it does not appear to be a significant predictor of football performance for backs in this investigation. It would appear that leg strength is a much more important variable for backs to possess than strength of the upper body.

The rope climb also involves a great deal of co-ordination. In the opinion of the investigator, the co-ordination aspect of the rope climb contributes more to the multiple correlation than does the strength aspect of the rope climb. It appears that a variable which was largely unrelated to the other variables, when the strength aspect was considered, would obtain high correlations with the other variables, had it been significant. For this reason, the investigator feels that the co-ordination aspect of the variable is the primary contribution of the rope climb to the multiple correlation. Co-ordination is very important to backs and ends if they are to perform the intricate and sequential movements required for winning performances.

Variable #11 (Twelve Minute Run)

The twelve minute run was the sixth variable to be entered into the multiple correlation equation. This correlation was significant at the .01 level and combined with the other variables a multiple correlation of .6629 was obtained. This variable also had correlations of .27 with

the game percentage score, .63 with the lateral jump, and .47 with lateral movement. The correlations with the lateral jump and lateral movement appear to be associated again with the ability to move one's feet. This investigator is a strong advocate of cardiorespiratory fitness. The twelve minute run is used as a part of the investigator's off-season program, because of the endurance fitness obtained.

Kollias (41) conducted an interesting investigation in which he found the average aerobic capacity (maximum oxygen intake) for football players was approximately 50 ml/kg/min, an average regarded as relatively low, particularly for backs who consistently participate in run and pass plays. The relatively moderate level of work and aerobic capacity observed for these athletes is a reflection of their conditioning regimen which consisted mainly of weight training and sprint running, with little emphasis of development of cardiorespiratory endurance. This investigator agrees with Kollias in regard to his assessment of the work loads placed upon football players. Most coaches do not take the time to do endurance fitness work during the regular season. This type of conditioning has been relegated into secondary importance by many coaches. This investigation reveals that additional research should be accomplished to try and ascertain if there is a real relationship between cardiorespiratory fitness and football performance.

The majority of football players cannot see the relationships between long distance running and football performance. Therefore, it takes a highly motivated athlete to work on this aspect of his conditioning. The athlete must be competitive, too, because he is usually only competing against himself to see how far he can run in the twelve minute period. The investigator also feels that mental discipline can

be determined through the use of this test. It takes a certain degree of discipline for a player to work on this portion of his conditioning when he has been told throughout his football career that long distance running is not as important as sprint running.

There is the possibility that when one tests a subject on the twelve minute run, he might also be testing him on the intangibles mentioned above. This investigator feels that an investigation correlating the types of variables mentioned with the twelve minute run is warranted. If the results are positive, it would give the coaches, for the first time, a physical test which could objectively measure these heretofore unmeasurable intangibles.

Variable #12 (Vertical Jump)

The vertical jump was the most consistent of the variables in regard to its correlation with the criterion variable. It had a correlation of .308 with the game percentage score which was the second highest correlation after lateral movement. The vertical jump also had a correlation of .56 with the forty yard dash. It was the eighth selection to be entered into the multiple correlation equation. Combined with the other variables the correlation of .7090 was significant at the .01 level. The vertical jump has long been one of the most significant and consistent variables in the prediction of athletic success in research studies performed in this area. Explosive power is certainly an asset to offensive backs in obtaining quick starts and to defensive backs as they make tackles. It was interesting to observe in this study that the black players as a whole performed better on the vertical jump than did the white players. The black players also exhibited the best times in

the forty yard dash. This would explain the high correlation of the forty yard dash to the vertical jump. The black athletes all had the prominent gluteals, a muscle group which provides powerful extension of the upper leg on the hip. The speed of a player might be improved if coaches would work their athletes on the development of this muscle group through weight training, emphasizing "dead lifts" and "squats." The execution of the vertical jump against added resistance would also help; for example, the athlete could execute a jump while holding dumb bells. By working to improve explosive power, the athlete should also be able to help his speed and quickness, the invaluable assets needed for successful performance.

Results Related to Line

(Tables IV and V)

As revealed by inspecting Table V, a very unusual multiple correlation existed between the 12 variables and their predictability of the game percentage score. The investigator realizes that a correlation this significant does not often occur. However, the data were checked and rechecked and the same results occurred in every instance. The only explanations that the investigator might construe are that a multiple correlation of .997 is possible, although not probable, considering the number of variables which were used for this investigation. Most of the variables are of an entirely different nature and, when they are combined and put into a multiple correlation equation, the possibility exists for such a correlation. The second explanation centers around the grading of the linemen. The offensive linemen as a group scored considerably lower on their game percentage scores than did the defensive linemen.

TABLE IV

CORRELATION MATRIX FOR LINE

Correlation of .456 Needed for Significance at .01

Variable Number	1	2	3	4	5	6	7	8	9	10	11	12	13
1	1.000	0.842	0.666	0.277	3.487	0.708	0.566	0.354	0.403	0.586	0.803	0.388	0.514
2		1.000	0.542	0.186	0.591	0.639	0.207	0.123	0.254	0.639	0.649	0.608	0.674
3			1.000	0.048	0.316	0.446	0.329	0.050	0.358	0.322	0.307	0.496	0.477
4				1.000	-0.113	0.200	0.534	-0.165	0.184	0.300	0.417	-0.146	0.323
5					1.000	0.597	0.001	0.127	0.033	0.460	0.459	0.781	0.282
6						1.000	0.339	0.042	0.055	0.551	0.768	0.437	0.414
7							1.000	0.346	0.616	0.243	0.461	-0.009	0.006
8								1.000	0.313	-0.208	0.090	0.041	-0.244
9									1.000	0.445	0.226	0.073	-0.206
10										1.000	0.673	0.177	0.165
11											1.000	0.196	0.465
12												1.000	0.526
13													1.000

This condition existed not necessarily because better athletes were on defense, but because the offensive linemen have many more assignments to learn. Therefore, more situations arise for mental mistakes. Their techniques are also more difficult to master. Generally speaking, in the opinion of the investigator, it is more difficult for an offensive lineman to execute his basic skills than it is for the defensive lineman to execute the skills essential for his position. To complicate the situation, the offensive linemen were by far the quickest of the two groups and performed better on most of the test variables. These two explanations might be a partial cause of the high correlation obtained. Another partial cause for the high correlation might be the fact that the line group had more variability in their game performance scores than did the backs. Whatever the reason, the investigator would not encourage anyone to accept the results of this study pertaining to the line positions without further investigation.

The lateral jump had a correlation of .51 with the game percentage score. It was the ninth variable entered into the multiple correlation equation and combined with the other variables produced a multiple correlation of .9977. The lateral jump produced consistently high correlations with the other 12 variables. For significance at the .01 level, the correlation, which had to be obtained, was .456. The lateral jump correlated high enough with eight other variables to be significant at the .01 level. The highest correlations were obtained with the bench steps, the twelve minute run, and lateral movement. These correlations were .84, .80, and .70, respectively. As does the lateral jump, all of these variables involve movement of the feet. It is the opinion of the investigator that "quick feet" are essential for successful line play.

A large amount of practice time is spent in drills to develop this quality. Although the line did not practice the lateral jump and other test variables involving the feet in the identical way in which the test was administered, the effect of practicing related drills might have had some effect on the external validity of the investigation. The emphasis placed on quick movements of the feet during practice could have definitely affected this portion of the investigation.

TABLE V

MULTIPLE CORRELATION COEFFICIENT WITH GAME PERCENTAGE SCORES (LINE)

Selection	Variable	Multiple Correlation
1	2	*.6741
2	9	*.7790
3	4	*.8213
4	3	*.8670
5	10	*.8985
6	8	*.9511
7	11	*.9788
8	6	*.9907
9	1	*.9977
10	12	*.9978
11	7	*.9979
12	5	*.9979

*Denotes this combination of variables to be significant at the .01 level.

The ability to move laterally for defensive linemen as they read the block of the offensive man and slide down the line of scrimmage to

make tackles is an important asset. Quick lateral movements of the feet are also used by offensive linemen as they "pass block" the defensive man. In pass blocking, the offensive man must use these quick lateral movements so that he can stay between the defensive man and the passer. Offensive linemen must also be able to move laterally to adjust to the stunts of the defensive man. All of these skills require practice and the results of this practice might have contaminated the investigation to a certain degree.

Variable #2 (Bench Steps)

Bench steps had the highest correlation with the game percentage score of any of the other variables. Bench steps were the best predictor of the game percentage score according to the results of the multiple correlation equation. A significant correlation of .67 was obtained. Correlations of .84, .64, and .63 were also obtained with the lateral jump, the twelve minute run, and lateral movement, respectively. The bench steps correlated highly with all the variables that required movement of the feet. The results obtained from this variable reinforce the investigator's opinion about the importance of quick feet to the line positions. The results of the bench steps were much more significant to the line than to the backfield group.

Variable #3 (Tuttle Pulse-Ratio)

A correlation of .47 was obtained with the game percentage score. The Tuttle pulse-ratio was the fourth leading predictor of the game percentage score, combining with the other variables to produce a multiple correlation of .8670. The Tuttle pulse-ratio also correlated .47 with

the game percentage score, .66 with the lateral jump, and .54 with bench steps. Although the results of the line group was more significant than the back group in regard to the Tuttle pulse-ratio, there is little evidence in this investigation to support the use of this test as a predictor of football performance. This investigator would be inclined to agree with the majority of research people who concur that the Tuttle pulse-ratio's biggest contribution is that of aiding in the detection of heart disturbances.

Variable #4 (Maximum Breathing Capacity)

Maximum breathing capacity was the third leading predictor of the game percentage score for linemen; combined with the first two variables a multiple correlation of .8312 was obtained. This placement was significantly higher than its ranking for the backfield group. Although research in regard to maximum breathing capacity and athletic achievement have not provided significant findings, the results of this investigation indicate further research is warranted.

A hypothesis for the greater significance of the maximum breathing capacity to the line group over the backs might exist in the fact that the linemen expend great amounts of energy in short bursts. Most often these bursts of energy are performed against resistance in the form of blocking an opponent, or delivering a blow to an offensive blocker and pursuing the ball. During the execution of these tasks, the lineman expends a great amount of energy and actually goes into "oxygen debt." This debt must be repaid so the lineman inhales and exhales forcefully, thereby allowing more oxygen to enter into the blood stream. It is logical to assume that the more air a player can move into and out of

the lungs, the quicker the debt can be repaid. It would not be expected that a lineman would exhaust his oxygen debt capacity while participating in an ordinary football game. However, if these small debts are not repaid, the onset of fatigue would occur much quicker, and thus, the performance of the player would be affected. Wright (42), in a study suggesting a procedure for measuring maximal oxygen debt, found a significant relationship between maximum breathing capacity and oxygen debt. Therefore, in actuality, this investigator might be obtaining a measure of the oxygen debt capacity of his subjects.

Variable #5 (Forty Yard Dash)

The forty yard dash was the twelfth and last variable entered into the multiple correlation. A correlation of .28 was obtained with the game percentage score. A very high correlation of .78 was obtained with the vertical jump. This correlation again points out the importance of explosive power in the performance of these two tasks. It also points out the need for extensive work in building the gluteus and hamstring muscle groups.

The relative position of the forty yard dash in its contribution to the multiple correlation was not expected by the investigator. However, the investigator feels that the grading procedure in which the offensive linemen are graded more critically might be a contributing factor to these results. It is suggested by the investigator that in future studies a large enough sample should be obtained so that the offensive and defensive linemen can be treated as separate groups. This investigator believes that quickness is the single most important asset for a lineman to possess. However, it is the ability of the lineman to

get downfield with speed that means the difference in a good play and a great play. Without speed in the offensive line, the offensive team is practically limited to an inside attack with limited blocking schemes. Without speed for pursuit, the defensive is handicapped, and technique is negated.

Variable #6 (Lateral Movement)

Lateral movement and the theorizing of its importance to linemen have been presented previously in the discussion of variable number one, the lateral jump. The lateral jump, as tested in this investigation, was over a much shorter distance than the lateral movement variable. However, the discussion of the importance of the lateral jump can also be theorized to the lateral movement variable as well, and reference to this discussion can be made. The treating of these two variables together in regard to their contribution to the game percentage score was strengthened as their intercorrelation was found to be .708. The twelve minute run produced a .803 correlation with lateral movement. The correlation with the game percentage score was .414.

Variable #7 (SCAT Series II)

The SCAT was the least significant of all the variables tested. The investigator's theory in regard to this was presented in the discussion dealing with this variable in the backfield group. An intercorrelation of .006 was exhibited with the game percentage score. It was the eleventh variable entered into the multiple correlation equation, and, in combination with the other variables, a multiple correlation of .9979 was obtained. However, the SCAT only raised the multiple

correlation .0001 over the tenth selection to be entered.

Intelligence appears to be important to successful performance for many reasons. A player's ability to reason and adjust to different situations which present themselves during a game and the affect of cutting down on the length of practice sessions appear to be two of the more important considerations. The intelligence variable is of primary importance to the coach when he considers his offensive and defensive systems. Coaches should not include strategies which are above the mental capabilities of his players. It would definitely be to the advantage of a coach to find out the mental capacities of his players. These statements are speculation on the part of the investigator and this knowledge was not gained through the battery of tests administered in this investigation.

Variable #8 (Body Reaction Time)

Body reaction time was the sixth variable entered into the multiple correlation equation, and combined with the first five, a multiple correlation of .9511 was obtained. A simple correlation of .24 was obtained with the game percentage score. The highest correlation for this variable, a correlation of .35, was obtained with the lateral jump.

The ability of a player to react and move his entire body is essential for athletic achievement. A defensive lineman who can react to the movement of the ball and, thereby, meet the charge of the oncoming blocker quicker and with more momentum has obtained an advantageous position over the blocker. The importance of body reaction time comes into play for an offensive lineman as he reacts to the stimulus of the starting count and responds with his entire body in the direction of

the course he wishes to assume.

Variable #9 (Reaction Time)

Reaction time was the second selection to be entered into the multiple correlation and together with the bench steps produced a correlation of .7790. A simple correlation of .616 was established with the SCAT. The importance of reaction time was discussed earlier and the significance of this variable was reaffirmed by its high predictability of the game performance score for the line group.

Variable #10 (Rope Climb)

The rope climb was the fifth variable entered into the multiple correlation equation. It was most highly correlated with the twelve minute run as a correlation of .673 existed. The rope climb is a good test for offensive linemen because it combines the two variables of strength and coordination. These two variables are the essentials of good blocking performance. A lineman who only has strength cannot take full advantage of this asset unless he can co-ordinate his movements so that this advantage can be exploited. On the other hand, a lineman who has perfect form and co-ordinated movements will not be as successful if he does not have a certain amount of strength to finish the task. There must be a balance between these two variables, and the rope climb accentuates the importance of one variable's function as it related to the other. Another good activity which points out the importance of combining these two movements is that of weight lifting. Strength is an important factor here, but, it is definitely negated without smooth co-ordinated movements.

Variable #11 (Twelve Minute Run)

The twelve minute run had a correlation of .46 with the game percentage score, and it was the seventh variable entered into the multiple correlation equation. In combination with the other variables a multiple correlation of .9788 was obtained. High correlations were obtained with the lateral jump and lateral movement. These two variables' correlations were .80 and .76, respectively. The same two variables also had the highest correlations with the back group. A general discussion of the importance this investigator placed upon the twelve minute run is presented in the previous section dealing with backs. The importance of endurance fitness to linemen cannot be de-emphasized. The ability to play with intensity throughout an entire contest, without undue fatigue, would definitely be an advantage to a lineman in the latter stages of the game. In the opinion of the investigator, this type of fitness has been grossly neglected by coaches. The results of this study, in regard to the twelve minute run, as they relate to linemen, indicate that coaches might gain sufficient benefits for their players if endurance fitness were included into the regimen of their workouts.

Variable #12 (Vertical Jump)

The vertical jump had the second highest correlation with the game percentage score. A correlation of .52 was obtained, and this was significant at the .01 level. In combination with the other variables a multiple correlation of .9978 was obtained. The highest intercorrelation existing with the vertical jump was the forty yard dash with a .78 relationship. These results were consistent with the findings as they related to the backfield group, too. The ability to "explode" from a

stance is an important ingredient in performing the forty yard dash. The distance is so short that a good start is essential if a good time is to be obtained. Therefore, it would appear that explosive power, as measured by the vertical jump, is an essential factor for good speed in the forty yard dash.

The explosive power of linemen as they come off the line of scrimmage would appear to be essential for successful line performances, too. The extension of the leg as a lineman charges out of his stance is similar to the explosion required for execution of the vertical jump. Therefore, the significance of the vertical jump to the game percentage score in this investigation points out the importance of the development of explosive power to successful line play. A future study in which a variable was included to more accurately measure the explosive power of a football lineman might help to confirm the findings in this investigation.

Results Related to Total

(Tables VI and VII)

Variable #1 (Lateral Jump)

The lateral jump was the tenth leading predictor of the game percentage score. Table VII reveals that as the lateral jump was entered into the multiple correlation equation, a .7081 correlation was obtained in combination with the other variables. The lateral jump had its highest correlations with the bench steps, the twelve minute run, and lateral movement, with correlations of .69, .63, and .56, respectively. These are the same three variables which had the highest correlations with the back and line groups. In the opinion of this investigator, at

TABLE VI

CORRELATION MATRIX FOR TOTAL

Correlation of .456 for Significance at .01

Variable Number	1	2	3	4	5	6	7	8	9	10	11	12	13
1	1.000	0.690	0.313	0.347	0.177	0.566	0.344	0.264	0.239	0.275	0.639	0.109	0.250
2		1.000	0.242	0.300	0.151	0.445	0.084	0.051	0.237	0.215	0.334	0.077	0.237
3			1.000	-0.158	0.222	0.295	0.068	0.081	0.304	0.235	0.129	0.369	0.267
4				1.000	-0.119	0.241	0.379	-0.086	-0.170	0.260	0.461	-0.183	0.225
5					1.000	0.649	0.288	0.346	-0.116	0.691	0.542	0.703	0.440
6						1.000	0.382	0.336	0.151	0.525	0.683	0.443	0.470
7							1.000	0.442	0.111	0.453	0.423	0.083	0.274
8								1.000	0.349	0.154	0.191	0.131	0.121
9									1.000	0.059	-0.062	-0.096	-0.201
10										1.000	0.562	0.349	0.372
11											1.000	0.290	0.467
12												1.000	0.501
13													1.000

least one of these variables could be dropped from the off-season conditioning program. Since all of these variables showed significant relationships at the .01 level, it would appear that working on all of these variables is repetitious and that time could be saved by deleting one of these variables from the program.

TABLE VII

MULTIPLE CORRELATION COEFFICIENT WITH GAME PERCENTAGE SCORES (TOTAL)

Selection	Variable	Multiple Correlation
1	12	*.5014
2	11	*.6035
3	4	*.6256
4	9	*.6351
5	3	*.6527
6	6	*.6611
7	5	*.6702
8	8	.6814
9	10	.6956
10	1	.7081
11	2	.7315
12	7	.7316

*Denotes this combination of variables to be significant at the .01 level.

Variable #2 (Bench Steps)

The bench steps were the eleventh variable entered into the multiple correlation equation, combining with the first ten variables for a multiple correlation of .7315. The highest correlations were with the

lateral jump and lateral movement, .69 and .44, respectively. These two variables were also the variables which correlated highest with the bench steps in the back and line groups. This reaffirms the investigator's opinion that one of these variables could be deleted without affecting the foot movement of the athlete.

The contrast of the bench steps' contribution to the total multiple correlation, and its contribution to the line multiple correlation, might be explained by the fact that the linemen practiced these skills indirectly during every practice session. Every drill for the line is started by having them move their feet as quickly as possible in short choppy steps, whereas the backs did not practice these skills as a regular part of their practice session. These results indicate that either the linemen's practice sessions are accomplishing what they are designed to accomplish, or the daily practice in related drills have contaminated the line sample. Further investigation into this area is recommended by the investigator.

Variable #3 (Tuttle Pulse-Ratio)

The Tuttle pulse-ratio was the fifth selection to be entered into the multiple correlation equation, raising the correlation .0176 to .6527. A correlation of .26 was obtained with the game percentage score, .37 with the vertical jump, and .30 with reaction time. The results of the Tuttle pulse-ratio are difficult to evaluate since it is a non-football related variable. Also, in the opinion of the investigator, heart rate recovery is a questionable variable to use in attempting to predict football performance. This assumption is based upon the fact that there is a 25 to 30 second "rest interval" between plays in a

regular football game. It would appear that a person with a "normal" heart condition should have little trouble with the heart rate recovery considering the periodic rest intervals and the nature of the activity which does not cause excessive heart rates. However, by inspecting the raw data (Table VIII, Appendix), it can be seen that the majority of the pulse-ratios are in the average fitness category. Therefore, if better pulse-ratios were obtained, the relationship of the Tuttle pulse-ratio might have been more significant. From this investigation, there is not enough evidence to accept or reject the Tuttle pulse-ratio as a significant predictor of football performance.

Variable #4 (Maximum Breathing Capacity)

A correlation of .22 was obtained between maximum breathing capacity and the game percentage score. However, it was the third leading predictor of the game percentage score, combining with the vertical jump and the twelve minute run for a multiple correlation of .6256. A correlation significant at the .01 level was obtained with the twelve minute run. The correlation between these two variables was .46. A high correlation was also obtained between these two variables in the back and line groups. This condition seems logical since maximum oxygen intake is an important aspect of the twelve minute run. The ability to displace as much air as possible should be an asset in the successful performance of this variable.

The more significant relationship of maximum breathing capacity to the line, over the backs, was discussed earlier in the section dealing with the line. It is difficult to evaluate the significance of maximum breathing capacity since it is a non-football related variable. This

investigator has theorized as to the importance of maximum breathing capacity, but it is merely speculation on his part. The results of this investigation give evidence to the possibility that maximum breathing capacity does contribute to the prediction of football performance. Therefore, continued research in this area seems warranted. It might be of particular interest in a future investigation to include oxygen debt as a variable since a relationship might exist between these two variables.

Variable #5 (Forty Yard Dash)

The forty yard dash was the seventh leading predictor of the game percentage score. It had a correlation of .44 with the game percentage score. This was the fourth highest correlation. A correlation of .70 existed between the forty yard dash and the vertical jump. This correlation was consistent throughout the investigation.

The forty yard dash is a statistic which was made popular by the professional teams. Their premise for the use of this distance as an indicator of speed is based on the fact that the forty is the approximate distance a player must sprint to cover punts and kickoffs. Basically speaking, forty yards is the maximum distance a player will be forced to run during a game unless an exceptional play occurs. Because of this emphasis placed on the forty, most high school and college coaches time their players in the forty yard dash. This emphasis has been so great that "good football players" and forty yard dash times are almost synonymous terms. The results of this study reveal that the possibility exists that an over-emphasis on forty yard dash times might be prevalent. There are examples of good football players, at every level of competi-

tion, who do not have good forty yard dash times; yet, coaches continue to use speed as the focal point in selecting their players. As the investigator stated earlier, the difference in a good football player and a good football player who achieves greatness, is speed. The difference in a good play for average yardage and a great play for long yardage is speed. Its value cannot be underestimated, but at the same time, there is a tendency to over-estimate its predictability of football performance. The professionals are looking for the great players because they must play against great players. They can and must be selective. College and high school coaches can get by with using players of lesser speed because of the competition they play. Therefore, the emphasis on speed by the professionals should not influence other coaches so significantly.

Variable #6 (Lateral Movement)

Lateral movement had the second highest correlation with the game performance score as a correlation of .47 was established. It was the sixth variable to be entered into the multiple correlation equation, combining with the other variables for a multiple correlation of .6611.

Lateral movement was a much more significant predictor of the game percentage score for backs than it was for the line. This condition probably existed because the distance to be covered in the lateral movement test was much greater (40 yards) than the distance to be covered in tests such as the lateral jump and bench steps. The linemen did somewhat better on these tests because speed did not enter as a factor, while it was a factor in lateral movement. Most of the drills in which lateral movement is involved for backs covers much greater distances

than those for the line. These circumstances might explain the differences in the placement of the two variables in the multiple correlation for the back and line groups.

Variable #7 (SCAT Series II)

The SCAT had a correlation of .27 with the game percentage score. It was the least significant predictor of the game percentage score of all the variables. It also ranked last for the back group and next to last in the line group in regard to its predictability of the game percentage score. The backs scored significantly higher than did the line on the SCAT. However, it was still a poor predictor of the game percentage score in that group. The investigator's rationale for the insignificance of this variable was presented in the discussion of the backs. From the results of this study, the investigator would concur with the majority of the research in this area which finds no significance in intellectual achievement and athletic performance.

Variable #8 (Body Reaction Time)

Body reaction time was the eighth variable entered into the multiple correlation equation. At this point, a multiple correlation of .6814 was obtained. An intercorrelation of .12 was obtained with the game percentage score. Body reaction time was a better predictor for the backs and line than it was for the total group. This variable was also a better predictor for the backs than for the line group. It is interesting to note (Table I) that the line scored better on the simple reaction time test, but the backs scored better on the body reaction time test. The investigator attributes these results to the greater

mass of the linemen.

In this investigation, body reaction time is not a top predictor of the game percentage score, nor is it one of the lower predictors. It is a better predictor for the individual back and line groups than for the total group. The body reaction time of an individual appears to hold some importance to game performance but not nearly as much as some of the other variables tested in this investigation.

Variable #9 (Reaction Time)

Reaction time was the most consistent predictor of the game percentage score. It was the fourth best predictor for the total group and, combined with the first three variables, a multiple correlation of .6351 was obtained. This correlation was significant at the .01 level. Reaction time was the second best predictor for the back and line groups with multiple correlations of .44 and .77, respectively. None of the other variables exhibited this kind of consistency. Reaction time is probably one of the most often used variables in tests of athletic achievement. Most researchers in studies of this nature have found significant relationships between reaction time and athletic achievement. The results of this investigation would certainly concur with those findings.

Variable #10 (Rope Climb)

The rope climb had a correlation of .37 with the game percentage score. It also had high correlations of .69 with the forty yard dash, .56 with the twelve minute run, and .52 with lateral movement. It was the ninth variable entered into the multiple correlation equation, and,

in combination with the other variables, a multiple correlation of .6956 was obtained. The rope climb appears to be a good test of combining several variables in one co-ordinated movement. It works many of the major muscle groups as the climb is being performed.

The investigator feels that this variable might possibly help the athlete in gaining confidence in himself. Many young men are afraid of heights; this test can possibly help a young man to gain a certain degree of self-confidence. During this test, the subjects yelled and offered more encouragement than for any of the other tests. The investigator felt that the test atmosphere for the rope climb was closer to the conditions in which the game percentage scores were obtained than were any of the other variables. He also felt that this condition helped the subject to perform at his peak efficiency. From the standpoint of the testing conditions, the investigator feels as though this test had very high external validity.

Variable #11 (Twelve Minute Run)

The twelve minute run had a correlation of .46 with the game percentage score. Correlations of .68 were obtained with lateral movement and .63 with the lateral jump. These two variables obtained the highest correlations with the back and line groups, too. The twelve minute run was the second leading predictor of the game percentage score. Combined with the lateral jump, a multiple correlation of .6035 was obtained. The philosophy of this investigator's beliefs in regard to the twelve minute run have been discussed previously. The relationship of the twelve minute run to the criterion measure in this study was sufficient enough, in the eyes of the investigator, to warrant further and intensive

investigations into this area. There has been little research in this area. One reason is because few coaches implement endurance conditioning into their practice regimen. Football players have been on weight training and sprint running programs for so long that it is difficult to instill in these players the value of endurance conditioning. Significant studies showing positive relationships between endurance conditioning and football performance are needed to instill confidence in players and coaches of the values derived from this type of training.

Variable #12 (Vertical Jump)

The vertical jump was the best predictor of the game percentage score for this investigation. A correlation of .5014 was obtained with the game percentage score. The vertical jump has long been associated with athletic success, and the results of this investigation confirm the findings of these previous studies. The vertical jump is an easy test to administer, and its value to coaches could be substantial in predicting the success of their prospective athletes. Coaches could administer the test in a short period of time and could obtain immediate feedback. Additional studies similar to this investigation are needed to confirm the predictability of the vertical jump to football performance.

A correlation of .70 was reached with the forty yard dash. The correlation of the forty yard dash with the vertical jump was significant at the .01 level in all three groups. If coaches could predict the forty yard dash from a player's vertical jump score, it would supply him with another means of predicting a player's potential success as a football player.

General Discussion

The results of this study do not concur with the results of the previous study by this investigator. In the previous study, the best predictors were the forty yard dash and the ACT composite scores. In this investigation, the forty yard dash was the seventh best predictor of the 12 variables utilized for the back and total groups. It was last in its predictability of the game percentage scores for the line group. Any comparisons made between these two studies would be difficult because of the distinct differences in the two populations utilized for each study. One possible explanation of results might be that the forty yard dash and intelligence, or academic achievement, are better predictors of football performance for major college players than for small college players. However, further intensive investigations need to be performed before such concrete statements can be made.

The study most similar to this investigation is the study by Mosteller (25). In Mosteller's study, the multiple correlation for the line revealed that the two best predictors of the game percentage score were lateral quickness and the bench steps. These two variables combined for a multiple correlation of .455. These results are similar to those of this investigation in that the bench steps were the leading predictor of the game percentage score for the line group. In the back groups for both studies, lateral movement was the leading predictor of the game percentage score. In Mosteller's study, the correlation was .38. Another interesting comparison which can be made in regard to these two studies concerns the forty yard dash variable. In both investigations, the forty yard dash was the least significant predictor of the game percentage score for the line groups. The results of these

two investigations appear to concur in their findings much more so than did the findings of the present investigation and the previous study at Oklahoma State University.

One of the primary purposes of this investigation was to attempt to identify those variables which were most predictive of football performance. The multiple correlation coefficient for backs (Table III) reveals that the Tuttle pulse-ratio, maximum breathing capacity, and the SCAT do not contribute enough to the multiple correlation for their inclusion in the prediction of the game performance scores for backs. Therefore, these last three variables could be dropped. The multiple correlation for the first nine variables resulted in a correlation of .7236 which was significant at the .01 level.

The multiple correlation for the line (Table V) indicated that the first six variables were almost as significant a predictor of the game percentage scores as was the entire 12 variables combined. The time spent testing for the other six variables would be questionable. The first six variables combined for a multiple correlation of .9511 while the last six only combined for an additional .0468.

For the total group (Table VII) the third through the twelfth variables contributed only minimally to the multiple correlation. The top two predictors, the vertical jump and the twelve minute run, combined for a multiple correlation of .6035. It is questionable whether the .1281 added to the multiple correlation by the remaining ten variables is sufficient enough to warrant the time needed for testing.

A short summary of other pertinent results reveal the following: (1) The variables with the highest correlation to the game performance score for the back, line, and total groups were the lateral movement

(.33), the bench steps (.67), and the vertical jump (.50), respectively. (2) It was found that the lateral jump had the highest overall inter-correlations with the other variables in the back and line groups. In the total group, the twelve minute run had the highest overall correlations with the other variables. (3) The multiple correlation for the backs was .7449, the line .9978, and the total .7316. (4) None of the variables for the backs group obtained high enough correlations with the game percentage score to be significant at the .01 level. For the line group, significant correlations were obtained by the lateral jump, bench steps, Tuttle pulse-ratio, the twelve minute run, and the vertical jump. For the total group significant correlations were obtained by the lateral movement and twelve minute run variables. (5) It was found that the skills involved for optimum performance were different for the back and line groups. Thus, separate test batteries should be utilized for these two groups for the development of skills which are essential for optimum football performance.

CHAPTER V

CONCLUSIONS

The results of this investigation warranted the following conclusions:

1. The first nine selections entered into the multiple correlation equation were deemed to be the best predictors of football performance for backs. These nine variables were the lateral movement, reaction time, body reaction time, lateral jump, rope climb, twelve minute run, forty yard dash, vertical jump, and the bench steps. These variables combined for a multiple correlation of .7236.

2. The first six selections entered into the multiple correlation equation were the most significant predictors of the game percentage scores for the line group. These six variables were the bench steps, reaction time, maximum breathing capacity, Tuttle pulse-ratio, rope climb, and body reaction time. These variables combined for a multiple correlation of .9511.

3. For the total group, the first two selections entered into the multiple correlation equation, the vertical jump and the twelve minute run, were the two best predictors of the game percentage score. A multiple correlation of .6035 was obtained with the combination of these two variables.

4. For the total group, the hypothesis, the lateral jump is not significantly related to the game percentage score of a football player,

was accepted.

5. For the total group, the hypothesis, the bench steps is not significantly related to the game percentage score of a football player, was accepted.

6. For the total group, the hypothesis, the Tuttle pulse-ratio is not significantly related to the game percentage score of a football player, was accepted.

7. For the total group, the hypothesis, maximum breathing capacity is not significantly related to the game percentage score of a football player, was accepted.

8. For the total group, the hypothesis, the forty yard dash is not significantly related to the game percentage score of a football player, was accepted.

9. For the total group, the hypothesis, lateral movement is not significantly related to the game percentage score of a football player, was rejected.

10. For the total group, the hypothesis, the SCAT is not significantly related to the game percentage score of a football player, was accepted.

11. For the total group, the hypothesis, body reaction time is not significantly related to the game percentage score of a football player, was accepted.

12. For the total group, the hypothesis, reaction time is not significantly related to the game percentage score of a football player, was accepted.

13. For the total group, the hypothesis, the rope climb is not significantly related to the game percentage score of a football player,

was accepted.

14. For the total group, the hypothesis, the twelve minute run is not significantly related to the game percentage score of a football player, was rejected.

15. For the total group, the hypothesis, the vertical jump is not significantly related to the game percentage score of a football player, was rejected.

16. For the total group, the hypothesis, no combination of the above variables would validly predict football performance, was rejected.

Recommendations for Future Studies

Further studies into the prediction of football performance are needed. There are very few studies, such as this investigation, which attempt to identify those variables which are most important to football performance. This investigation yielded some interesting results which warrant further investigation. It would be interesting to see if a future investigation in this area would yield the same results to help establish its reliability.

In future investigations, those variables which proved to be good predictors of football performance should be retained. Variables which might be added should probably include a leg strength test to measure knee and hip extension strength. The vertical jump was a significant predictor of the game percentage score in this investigation; therefore, a leg strength test which measures extension of the knee and hip might help to confirm the importance of explosive power to game performance. Grip strength might also be an interesting item to include in future studies. Another variable which should be considered is the striking

force of a subject. A device known as an accelerometer which measures how many pounds of force a subject can exert could be used. This variable would combine the time it would take the subject to move the required two to three feet to strike the device, while also taking into account the weight of the individual. Thus, the striking force of the individual could be obtained. A future investigation might also consider the use of an instrument to measure those intangibles which are hard to measure but which are, none the less, essential to football performance, namely, variables such as desire, determination, motivation, perserverance, and co-operation.

The results of this investigation revealed the skills involved for optimum performance in the back and line groups. Therefore, in future studies, investigators need to be aware that the line and backs should be treated separately and that different tests are needed for the prediction of football performance. Because of this, it is suggested by this investigator that future studies might include enough subjects so that the population could be grouped into specific positions rather than into two groups such as was the case for this investigation. Valuable results might go undetected by combining the line and backs into groups without consideration being given to each individual position. This investigator is still of the opinion that the most valid means of determining a good football player is by viewing the game film of the participant. However, a modification in the procedure used for this investigation might be devised to include a means of awarding participants for exceptional plays. Instances where a player made two blocks on the same play, or a case of an offensive back making a good "move" to avoid a tackle are situations

whereby the awarding of an additional plus might be more indicative of the game performance of an individual.

The game percentage scores of the subjects could also have been influenced by the abilities of the opposition. The investigator believes that when the entire season is considered the various levels of abilities of the opposition will even out, and a player will play over as many "good" players as he will "poor" players. However, ideally, a study such as this investigation might be more reliable if it were carried out over a period of two or three years. The reliability might also have been strengthened by using more than one coach in the grading of the film.

The inclusion of the above recommendations might make it possible to better predict the game performance of players. If so, these results would be an asset to any coach in selecting those variables which are essential to his athletes if they are to perform at acceptable levels. These results would also help coaches to become more objective in their selection of players. In general, the results of this type of investigation could be very helpful to coaches. However, coaches need to utilize more of the studies and information available to them, too. Those variables which can be identified as good predictors of football performance should be developed to their fullest extent to enhance the chances of an athlete performing to the best of his ability.

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TABLE VIII

RAW DATA

Subject	1	2	3	4	5	6	7	8	9	10	11	12	GPS
1L	53	35	2.453	200	5.28	11.0	36	.310	.121	12.2	6.50	21	70.6
2L	64	41	2.289	216	5.18	10.0	51	.238	.128	10.9	7.25	24	80.8
3B	57	36	2.510	152	5.01	10.3	57	.140	.121	8.7	6.75	24	83.0
4B	56	35	2.180	134	4.81	10.3	63	.228	.115	8.3	7.00	30	77.0
5B	57	34	2.423	140	5.20	10.5	66	.204	.122	12.7	6.50	26	76.4
6L	61	38	2.457	164	5.36	11.2	45	.182	.106	12.7	6.50	21	67.7
7B	58	34	2.742	140	4.90	10.2	57	.138	.112	10.7	6.50	26	57.7
8B	60	41	2.346	174	4.65	10.0	45	.202	.134	10.9	7.00	31	75.5
9B	59	34	1.965	182	4.78	10.8	69	.164	.166	9.0	7.00	26	78.7
10L	54	38	2.750	150	5.03	10.8	30	.190	.118	12.7	6.00	30	73.7
11B	57	40	2.890	122	4.78	10.1	33	.158	.096	11.0	6.50	26	74.2
12B	41	33	2.540	162	5.01	11.5	51	.268	.139	9.8	5.50	24	67.4
13B	54	31	2.141	208	4.80	10.1	54	.198	.129	11.1	7.00	24	78.1
14B	57	39	2.394	198	5.04	10.7	45	.280	.140	12.0	7.25	22	60.0
15L	58	36	2.651	138	5.11	10.6	30	.174	.145	17.6	6.50	26	78.8

TABLE VIII (CONTINUED)

Subject	1	2	3	4	5	6	7	8	9	10	11	12	GPS
16B	54	38	1.465	168	4.85	10.3	57	.176	.137	10.7	7.00	26	82.1
17B	61	42	2.484	156	4.86	9.9	75	.162	.114	9.0	7.00	23	80.0
18B	59	35	2.428	188	4.93	10.9	45	.180	.104	9.8	6.75	23	64.0
19B	50	29	2.928	96	4.76	10.6	33	.264	.147	9.9	7.00	31	79.0
20L	63	39	2.409	146	5.00	10.4	36	.178	.118	9.5	7.00	24	60.6
21L	59	39	2.925	120	5.38	10.8	27	.274	.135	13.0	6.00	23	74.7
22B	57	38	2.486	168	4.78	9.9	48	.220	.128	8.9	6.50	27	72.5
23L	56	37	2.244	225	5.18	11.1	39	.226	.132	12.6	6.25	23	72.3
24L	56	37	2.515	114	5.11	11.0	36	.190	.122	13.2	6.00	25	60.4
25L	57	35	2.320	172	5.45	11.1	66	.156	.113	16.9	6.00	23	61.4
26L	61	38	2.302	164	5.15	10.8	51	.238	.127	11.1	7.00	24	74.1
27B	65	41	2.375	198	4.86	10.1	54	.236	.147	9.0	7.00	24	73.6
28L	61	39	2.422	140	5.02	10.3	51	.160	.110	10.5	6.75	26	65.3
29L	57	37	2.531	166	5.32	11.1	54	.160	.111	13.0	6.00	19	53.0
30L	41	31	2.140	96	5.45	11.5	36	.286	.125	16.9	5.50	19	55.3

L denotes lineman
B denotes back

VITA /

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