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Analysis of the Motor Fitness and Strength of the 1992 through 1995 Western Michigan University Football Teams

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ANALYSIS OF THE MOTOR FITNESS AND STRENGTH OF THE 1992 THROUGH 1995 WESTERN MICHIGAN UNIVERSITY FOOTBALL TEAMS

by

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ANALYSIS OF THE MOTOR FITNESS AND STRENGTH OF THE 1992 THROUGH 1995 WESTERN MICHIGAN UNIVERSITY FOOTBALL TEAMS

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The purpose of this study was to determine the motor fitness and strength characteristics of the 1992 through 1995 Western Michigan University football teams. Specifically, performance of the class of 1995 and various playing positions were compared to the performance of the entire team over a 4-year period. Approximately 100 members of the 1992 through 1995 Western Michigan University football teams were measured on tests that determined physical strength and motor fitness ability. These tests included the bench press, squat, hang clean, 20-yard shuttle run, 40-yard dash, vertical jump, and 300-yard shuttle run. ANOVAs or chi-square tests were calculated to determine if a significant difference existed among the variables. The entire team showed little improvement over a 4-year period for both the strength and motor fitness tests. The class of 1995 improved significantly ($p < .05$) over the first 2 years of eligibility. The skill position players scored significantly ($p < .05$) higher on the motor fitness tests than the power position players. The power position players scored significantly ($p < .05$) higher on the physical strength tests than the skill position players. These results could be used to produce more effective physical strength and motor fitness development programs. Training and testing regimens must be developed that are oriented toward sport-specific tasks.

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Erick W. Schork

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CHAPTER I

INTRODUCTION

During the late 1960s and 1970s professional football teams began to hire strength and conditioning coaches (Hendrick, 1996). Originally the purpose of these coaches was to condition the athletes to reduce the potential for injury and to increase the potential for a more successful football season. The success of teams with strength coaches became known due to their successful seasons year after year. Today all professional football teams and most NCAA Division I and I A teams employ strength coaches. Most collegiate teams have had strength coaches working with their teams for the past 5 to 10 years.

The current focus of college strength coaches is the same as that of the professional coaches: improve performance and reduce the risk of injury. The two primary goals for improving performance include increasing power and improving overall motor fitness. Free-weight multi-joint exercises are used in both the training and the testing for sport-specific strength development. A component of motor fitness that is emphasized in a football conditioning program is agility. Agility is the ability to move quickly and easily. There is no question that improving agility will enhance performance on the football field. Training for agility will accomplish many objectives of the strength coach; it will enhance power, speed, coordination, and increase aerobic endurance. College strength and conditioning for football teams is designed to be functionally based on the demands of the game of football. The coaches employ a scientific foundation of training principles to develop the strongest and best conditioned football athletes

possible, the primary goal.

Statement of the Problem

The problem was to determine the motor fitness and strength characteristics of the 1992 through 1995 Western Michigan University football teams. Specifically the performances of the class of 1995 and various playing positions were compared to the performance of the entire team.

Delimitations

The following delimitations were established for this study:

1. The participants were approximately 100 male Western Michigan University student athletes who participated during the 1992 through 1995 college football seasons.

2. The strength tests that were used included the bench press, power squat, and hang clean lifts.

3. The motor fitness skills evaluated included the 20-yard shuttle run (pro agility), 40-yard dash, vertical jump, and 300-yard shuttle run.

4. The statistical design for this study assumed independent groups existed across the four years, 1992 through 1995. However, the groups were not completely independent or dependent. Some members of the team or the class of 1995 were the same across consecutive years; other members were not.

5. The times for the speed and agility tests were recorded using a hand-held stopwatch.

6. All of the agility and speed testing was done on a hardwood surface or on the indoor track in Read Fieldhouse, Western Michigan University.

7. The strength testing occurred in the Read Fieldhouse weight room or Waldo

Stadium weight room, Western Michigan University.

Limitations

This study was limited by the following:

1. Only one National Collegiate Athletic Association (NCAA) Division I Collegiate football team participated in the study, so generalizations could not be made to other populations.

2. The psychological effects resulting from the unnatural surroundings of the testing environment could affect the subjects' scores on both the strength tests and the motor fitness tests.

3. The data for this study were not collected for the purpose of this investigation. Although it was believed the tests were administered the same from year to year, the standardization procedures for each test were assumed to be the same from year to year.

Assumptions

The following assumptions were made about this study:

1. The subjects gave their best effort on each test.

2. The subjects were free of any injury that could hinder their performance on each test.

3. Tests were administered according to the instructions associated with each instrument, and thus scores were objective from year to year.

Hypotheses

The following hypotheses were established for this study:

1. No difference in motor fitness performance was observed for the entire team

over a 4-year period.

2. No difference in strength performance was observed for the entire team over a 4-year period.

3. The motor fitness performance for the class of 1995 improved over the 4 years.

4. The strength performance for the class of 1995 improved over the 4 years.

5. The skill positions' motor fitness performance did not improve over the 4-year period.

6. The power positions' motor fitness performance did not improve over the 4-year period.

7. The skill positions' strength performance did not improve over the 4-year period.

8. The power positions' strength performance did not improve over the 4-year period.

9. Motor fitness scores for the skill position players were different from the power position players.

10. Strength scores for the skill position players were different from scores for the power position players.

Definition of Terms

The following terms were operationally defined for this study:

1. Bench press strength test: The subject assumes a prone position on the bench with the knees bent and the feet flat on the floor, buttocks and shoulder blades in contact with the bench, the arms extended 90°. With the hands on the bar, the grip slightly wider than shoulder width, the bar is lowered to the chest, where it is held momentarily and

then extended to the starting position.

2. Class of 1995: The class who were studied for 4 years of eligibility. Their eligibility ended in 1995.

3. Hang clean strength test: The subject starts with the weight above extended knees, then dips and extends explosively from the knee, hip, and ankle joints while pulling the bar vertically upward in a straight line. The pull starts in an explosive shrugging action of the shoulders and concludes with an upward pulling action with the arms. Once the bar is pushed and pulled to its highest point, the athlete simply drops under the bar to catch it on the anterior portion of the shoulders.

4. Power position players: The players on the football team who require great power and overall strength in order to be successful. These players include the offensive and defensive linemen.

5. Repetition maximum (RM): The maximum amount of weight that can be lifted for a preset number of times.

6. Squat strength test: From a standing position, the subject lowers the buttocks until the thighs are at least parallel to the floor. At this position the body pauses momentarily and then returns to the starting position.

7. Skill position players: The players who require great speed and agility in order to be successful. These players include the offensive and defensive backfield players, as well as the receivers.

8. 300-yard shuttle run test: This test measures anaerobic endurance. The subject was required to run 300 yards as fast as possible. The 300-yard shuttle run was repeated 5 times with 30 seconds recovery between each run.

9. 20-yard shuttle run test: The agility of the subject was measured by running 20 yards between three cones placed 5 yards apart. The subject started at the center

cone, moved 5 yards to his right, then moved 10 yards to his left, and then moved 5 yards to his right toward the center cone. The time the athlete was able to change direction and accelerate back to the starting line determined his agility score.

CHAPTER II

REVIEW OF LITERATURE

Introduction

An intercollegiate football player at the Division I level must be a dedicated and hard working athlete. The demands required of an athlete to prepare himself both physically and mentally are extensive. He must maximize his motor performance ability level in the following areas: speed, agility, flexibility, power, explosiveness, and strength. These characteristics can be increased and are easily measured. For football players the importance of the development of these abilities is twofold: (1) a stronger, faster, more agile athlete is a better performer; and (2) the stronger athlete is less susceptible to injury.

A successful strength and conditioning program provides football players a feeling of confidence that they will be physically ready when they step on the playing field. The development of motor fitness provides a player the confidence that no one will be able to physically overpower him in a game situation.

Physiology of Strength Training

Strength is the ability to produce maximal force, which may result in movement. Any movement requires strength to some degree. Football is a game of controlled violence and collision. The nature of the game dictates that each player be as strong as possible in order to maximize playing performance. In situations in which one player

attempts to move another, escape from another, or stop another, the possession of adequate strength is a vital asset. If all else is equal, the stronger football player will dominate the weaker and the stronger team will win (Hay, 1993).

Strength training, like any other form of physical conditioning, must adhere to sound physiological guidelines in order to be totally effective. This means that strength coaches must be aware of certain basic principles that govern strength development.

A muscle is comprised of a number of individual muscle fibers. The number of fibers within muscles may vary greatly (Carola, Harley, & Noback, 1990). Larger and stronger muscles have more muscle fibers, and smaller and weaker muscles have fewer. A group of muscle fibers that is innervated by a single motor neuron is called a motor unit. Muscle fibers within a specific motor unit contract on an "all-or-none" basis. Muscle fibers that are innervated by a specific motor neuron either contract completely or not at all. The greater number of motor units an athlete activates, the greater the number of muscle fibers recruited, resulting in a stronger contraction. The amount of resistance or stress placed upon a muscle will determine the number of motor units and muscle fibers that are recruited to complete the task. Therefore, lifting heavy weights when training will result in the recruitment of a large number of muscle fibers. The muscle fibers recruited are used to overcome the resistance provided by the weights and will adapt physiologically (Carola et al., 1990).

As an exercise is repeatedly performed, the muscle fibers that were initially called upon for the first few repetitions (reps) begin to fatigue, resulting in the recruitment of additional motor units and muscle fibers (Carola et al., 1990). Therefore, lifting heavy weights in series or sets will result in a more complete use of the muscle fibers in the exercised muscle.

In order for an athlete to become stronger, he must also use the progressive

overload principle (McArdle, Katch, & Katch, 1991). First, he must place a stress upon the muscle that is greater than normal. Once the muscle has adapted to this stress and has reached a new level of strength, the athlete must again stress the muscle at a higher level. This stress-adaptation-stress cycle must be used so that the athlete can progress to a higher level of strength. This is accomplished by increasing the resistance or repetitions for a given exercise (Woicik, 1989).

Variables that are manipulated in a lifting program to achieve the desired result are, sets, reps, and rest (Woicik, 1989). A set is a series of repetitions for a given exercise performed continuously. A repetition is one complete movement cycle for a given exercise. Rest between sets is the time allowed to recover after one set in preparation for the next.

The human body is capable of adapting to the stresses that are imposed upon it provided adequate rest is permitted between training sessions. During this rest period the athlete's musculature recovers from the stress imposed by the workout and rebuilds to a new level of strength (Baechle, 1994). The rest period between training sessions should be no less than 48 hours and no greater than 96 hours. A recovery period that is less than 48 hours will not allow the muscle to fully recover from the workout. However, a rest period that is greater than 96 hours will cause the effects of the previous workout to reverse and will cause the athlete's strength level to decline to its previous level (Baechle, 1994).

To develop muscular strength with isotonic equipment, three to five sets of an exercise should be performed (McArdle et al., 1991). For pure strength one to three reps per set is most effective. For a combination of strength and endurance the athlete should perform four to eight reps per set. For the development of muscular endurance the athlete should perform 10 or more reps per set (McArdle et al., 1991).

There will come a time in every athlete's training program when he will encounter a training plateau (Gettman, Ward, & Hagan, 1982). The plateau is a point where the athlete finds it difficult to make strength gains in his program. Sometimes an athlete plateaus because he is not doing the proper amount of work in the weight room. If the athlete is doing too much work at submaximal intensities, then the solution would be to cut down the number of sets and reps and exercises and increase the intensity or resistance. When the athlete is not doing enough work, the number of reps, sets, and exercises needs to be increased. Regardless of the reason for the plateau an athlete must overcome the "slump" in training if he is serious in his quest for strength.

Strength Programs for Football Players

A complete weight training program for a football player consists of base lifts and assisted lifts (Woicik, 1989). The base lifts are the cornerstone of the program. They require the most effort and concentration. The assisted lifts are designed to support base lifts by strengthening isolated muscle groups, tendons, and ligaments to reduce the athlete's risk of injury.

Base Lifts

Multi-joint free-weight exercises that involve large amounts of muscle recruitment are considered base lifts (Davis, Frank, & Whipp, 1979). These lifts include the Olympic lifts and power lifts. Base lifts should be performed when the athlete is in a fresh state and has not completed any isolated exercises such as biceps curls. Olympic lifts are ballistic in nature and occur with a toe to head movement sequence. Examples of Olympic lifts include the power clean, snatch, and jerk exercises. Power lifts are slow and controlled and are more isolated anatomically. Examples of Power lifts include the

bench press, squat, and deadlift exercises. An increase in strength and power is the result of performing base lifts.

Power is often defined as the ability of an individual to apply maximum explosive force during movement in the smallest amount of time (Davis et al., 1979). This type of movement is desired in many sports, such as track and field, gymnastics, volleyball, and football. Explosive power gives the athlete the ability to jump higher, run with greater acceleration, throw with more force and tackle with greater impact force. Power can be developed through the use of Olympic lifts such as the hang clean and power clean exercises.

The hang clean is a multi-joint exercise that incorporates all of the body's major muscle groups. The basic principle of the hang clean is to vertically accelerate the barbell to a sufficient height to be able to rapidly move under the bar and gain support of the bar on the anterior part of the shoulders (Woicik, 1989). The hang clean also strengthens the connective tissue of the exercised joints as the body adapts to the demands placed on it. In order to perform the clean exercises, instantaneous contraction and relaxation of multiple muscles takes place. This adapts the neuromuscular system to facilitate the movements that require power (Derwin, 1990).

The bench press and squat exercises also contribute to the development of muscular strength and endurance, flexibility, balance, and decreased risk of injury. The bench press and squat exercises recruit many of the body's major muscle groups. Power lifts also have a positive effect on the neuromuscular system and transfers well to the neuromuscular demands of sport competition (Derwin, 1990).

Assisted-Lifting Exercises

Assisted-lifting exercises are supplementary exercises and are performed toward

the end of the training session. These lifts exercise the muscle groups that do not receive specific attention by training with the base lifts. Assisted-lifting exercises are included in a strength and conditioning program to complement the base lifts. Assisted lifts help to develop the body's musculature symmetry. Many of the assisted-lifting exercises involve modalities designed to decrease the risk of injury to the neck, hamstrings, ankles, knees, and shoulders (Woicik, 1989). Examples of assisted lifts used in football strength training include triceps extensions, hyperextension, single leg squats, leg extensions, leg curls, forearm exercises, and neck exercises.

Motor Fitness Training

In games like basketball, soccer, baseball, tennis, and football, success and failure often comes down to the "moment of truth," a point in the contest when the offensive outmaneuvers the defense or the defense shuts down an offensive drive. In most instances this movement is determined by the players' movement speed and their ability to apply that speed to crucial game situations. Traditional thinking dictates that "sprinters are born, not made." This statement is true to an extent, but it is not possible to be a world-class sprinter or record-breaking running back without utilizing good sport science, good coaching, and effective practice.

Physiology of Agility and Speed

Agility is the ability of the athlete to stop, start, and change direction of body movements of less than 10 s in duration (Kenyon, 1994). Speed is the body's displacement per unit of time. From a football perspective, agility is referred to as the ability to change direction quickly and easily (Kenyon, 1994). Training for agility and speed improves power, balance, and coordination. Agility and speed training also

enhance aerobic endurance and increase the ability to repeat high intensity work intervals. Power, balance, speed, and coordination skills are taught and improved through repetition. A low center of gravity, with knees bent and torso erect, is essential for making explosive movements (Woicik, 1989). All of the agility and speed drills that are used in a football conditioning program are developed from the functional demands of game situations. Agility and speed training are scientifically based and used to develop the strongest and best conditioned athletes possible.

Physiological training for agility and speed requires the use of the phosphagenic energy system (McArdle et al., 1991). The phosphagenic pathway is the most powerful of the energy pathways, and over 90% of the energy from football comes from this pathway. It is beneficial to spend over 90% of the training time focused on the use of phosphagenic energy system. Energy can be supplied from this energy system for about 8 s to 10 s. After an intense work interval in which the phosphagenic system has been depleted, it can take over 60 s to replenish 87% of the system's capacity. If exercise is continued at maximal effort beyond the capacity of the phosphagenic system, the lactic acid system is the energy source used to sustain the activity up to about 40 s. Without oxygen present, lactic acid accumulates and performance usually declines (Barnes & Attaway, 1996). Speed and agility training condition these systems to work at a higher level.

Anaerobic strength endurance is the ability to repeat intense, all out exercise using the anaerobic metabolic pathways. Controlling the work to rest ratio is important in designing training drills specific to anaerobic strength endurance. For training the phosphagenic system, the work to rest interval is 1:3 (Barnes & Attaway, 1996). For example, if the work interval for the agility and sprint patterns is 20 s, then the rest interval for this work should be 1 min.

More fast twitch, or Type II, muscle fibers are recruited for high velocity movements and high power output situations that are short in duration. More slow twitch, or Type I, fibers are utilized in slower movements that require a lower power output. The recruitment order is dictated by the size principle. The smaller slow-twitch fibers are recruited before the large fast-twitch fibers (Carola et al., 1990).

When training for agility and speed, an all out effort is required to produce the best results. In agility and sprint training, more fast-twitch muscle fibers are recruited. In order to recruit as many fast-twitch fibers as possible, the drills must require quick and explosive movements.

Agility and Speed Drills and Technique

It is important to understand some basic concepts when describing agility and speed training techniques. Some of the key concepts that will be discussed include acceleration, deceleration, and power. Acceleration is an increase in velocity or speed (Hay, 1993). An example of acceleration would be a running back coming out of his starting position. Deceleration is a decrease in velocity or speed. An example would be a wide receiver sprinting down field then decelerating to stop and quickly turn right or left. A powerful athlete has the ability to produce the greatest amount of force in the smallest amount of time, thus accelerating quickly. This starting power is the result of the athlete recruiting fast-twitch fibers in order to initiate a movement explosively.

Drills that are specific to agility include the box drill, pattern run, and lying bag. The box drill consists of four cones placed in a 5-yard by 5-yard square. The coach determines the movement changes at each cone and uses cue words such as "back," "forward," and "shuffle" to direct the athlete. This drill can be set up in many different patterns by arranging cones to depict a specific pattern. For example, the cones can be

set up in an "L" shape to simulate a halfback making a cut out of the backfield. The lying bag drills consists of several movement patterns over elevated obstacles. Each bag is placed approximately 1 yard apart. The directions in which the athlete passes over the bags include forward, backward, and lateral. Some examples of the movements include placing one or both feet in the space between the bags when running, weaving left to right, shuffling, weaving forward, backpedaling, and sliding laterally with both feet touching down in the space between the bags. Lying bag drills emphasize power.

Considering the large number of average athletes participating there is a tremendous potential for improving sprint speed among athletes in sports in which speed is required. The components of running speed are stride frequency, stride length, form, speed endurance, reaction time, acceleration, strength, and power. All of the factors that determine speed can be improved by practice. However, an elite Division I athlete may be able to improve in only one or two areas, such as strength and stride frequency. Resistive training may be used to increase stride length. Resistive training methods vary from uphill running, sled towing, or parachute towing, to running in the sand, snow, or water.

Improving stride frequency can be accomplished through being towed at a faster pace than is typical, for example, running downhill, or treadmill running. Reaction time, acceleration, strength, power, and endurance may all be affected by a weight training and plyometric program because of the close relationship they share with the neuromuscular system (Baechle, 1994).

Summary

In the development of a strength and conditioning program, it is important to remember that no one is to immediately begin training with the advanced drills of either

strength development or speed and agility enhancement. The program must follow a progression. At the beginning of a strength training program, it is important to start the athlete with high volumes or many different exercises and low intensities. As the athlete becomes stronger, it is important to decrease the volume (reps and exercises) and increase the intensity (resistance) to facilitate gains in strength. A progression is also important in developing motor fitness skills. When the athlete is introduced to agility and speed exercises, he should be advised to perform the movements slowly and under control. This will allow the athlete to learn proper technique and reduce the risk of injury, such as turning an ankle or spraining a knee. Proper progressions to these exercises or drills are required in order for the athlete to benefit from the strength and conditioning program.

A successful strength and conditioning program tries to improve the strength, agility, and speed by constantly making needed adjustments to the established program. It is essential that athletes and coaches have the resources to safely and effectively conduct these programs. It is primarily the responsibility of the strength and conditioning coach to be able to identify the needs and available resources and manipulate the environment for the athletes' safety and success.

CHAPTER III

PROCEDURES

The problem was to determine the motor fitness and strength characteristics of the 1992 through 1995 Western Michigan University Football teams. Specifically motor fitness and strength scores for the class of 1995 and various playing positions were compared to the motor fitness and strength scores for the entire team for each year. This chapter is organized into the following headings: (a) Subject Selection, (b) Testing Procedures—Strength and Motor Fitness, and (c) Research Design.

Subject Selection

Participants in the study were college, male, student athletes between the ages of 18 and 23 years. The subjects were from the 1992 through 1995 Western Michigan University Division I A football teams. The class of 1995 was composed of: (a) all 1st year eligibility players who participated in 1992, (b) all 2nd year eligibility players who participated in 1993, (c) all 3rd year eligibility players who participated in 1994, and (d) all 4th year eligibility players who participated in 1995. Therefore, members of the class of 1995 were not always the same members each year due to transfers, redshirt players, or drop outs. The data from each year of the 4 years the class of 1995 competed were treated as independent groups. The data were not originally collected for the purpose of this investigation. Therefore, only those strength tests and motor fitness tests that were measured for all 4 years, 1992 through 1995, were used in this study.

Testing Procedures

All testing was completed in the Read Fieldhouse weight room or the Waldo Stadium weight room at Western Michigan University. The strength and conditioning records were used as the primary source of data. The strength and conditioning records included strength and agility data that were used to monitor and evaluate the physical development of the Western Michigan University football teams. All data were collected by the strength coaching staff at Western Michigan University for each of the respective years, 1992 through 1995.

Strength Tests

Three strength tests—bench press, squat, and hang clean—were measured for each member of the football teams for years 1992 through 1995. The initial weight lifted for each of the three tests was established in the same manner. Based on the lifting program of each player at the time of the strength testing, the player estimated the amount of weight he could lift for 3 to 5 reps. The estimated weight was then lifted as many times as possible. If the athlete was unable to lift 3 reps or lifted more than 5 reps, the weight was adjusted, and he was retested after a 5-minute rest period. This procedure was repeated until a 3 to 5-RM was established. The weight lifted for the 3 to 5-RM was then used to predict the subject's 1-RM. The prediction was based on a formula by Dr. Scholl (personal communication, 1992), the former team physician. The formulas for 3, 4, and 5 reps are presented in Table 1. For each of the three strength tests, the predicted 1-RM served as the subject's score. A description of each of the three strength tests and the procedure for testing. All of the strength tests were administered using Olympic bars, squat racks, and benches, from Life Extension

Company, Kalamazoo, MI.

Table 1

Prediction Formulas for a 1-RM

Reps	Predicted 1-RM
3	0.917/wt
4	0.885/wt
5	0.857/wt

Note. Wt is the weight.

Bench Press Test

In the proper technique for performing the bench press, the subject lay supine on a bench with the knees bent and the feet flat on the floor. The buttocks and shoulder blades remained in contact with the bench throughout the entire range of motion of the exercise. The subject's hands were placed on the bar so that the wrists were over the elbows when the bar was in the down position. The bar was then lowered directly over the chest at approximately nipple level. When pressing to the starting position, the subject pressed the bar upward and slightly arched the back toward the shoulders.

Squat Test

The proper technique was explained to each subject prior to the test. The subject was required to place the feet slightly wider than shoulder width apart with the toes pointed slightly outward. The weighted bar was placed across the upper back. Bending at the hips and knees so that the buttocks moved backwards, the subject lowered the

hips until the thigh was parallel to the floor. A pause followed this movement, then the lifter returned to the starting position. For safety, good posture was stressed throughout the course of the exercise.

Hang Clean Test

The proper technique was explained to the subjects prior to the test. In the proper technique, the athlete started the lift by holding a weighted Olympic bar over the knees in a standing position. The subject then pulled the bar vertically to a point where it would be possible for the subject to position his body to catch the weighted bar on the anterior portion of his shoulders.

Motor Fitness Tests

Four motor fitness tests were measured for each member of the 1992 through 1995 Western Michigan football teams: (1) 40-yard dash, (2) 20-yard shuttle run, (3) 300-yard shuttle run, and (4) vertical jump. The purposes of these tests were to measure power, endurance, speed, and agility.

40-Yard Dash

The 40-yard dash was used to measure speed. The subject assumed a football stance. The clock started at the subject's initial movement to execute the dash. The clock was stopped when the subject crossed the 40-yard mark. The athlete was allowed two trials to perform the 40-yard dash. The faster time of the two trials served as the subject's score. This test was performed on the indoor track, and the subjects were required to run the distance alone.

20-Yard Shuttle Run

The 20-yard shuttle was administered to measure agility. The site for the 20-yard shuttle run consisted of three cones placed consecutively 5 yards apart. The subject started the test by facing the middle cone. With the subject's first movement, the clock was started. The subject sprinted to the left cone, touched it, and then sprinted past the middle cone to the right, touched the right cone and ran back to the middle cone. The test was terminated when the subject passed the middle cone. This test was performed on the hardwood floor in Read Fieldhouse, and the subject was required to run the distance alone. The athlete was allowed three trials; his score was the best of the three trials.

300-Yard Shuttle Run

The 300-yard shuttle run test was used to measure anaerobic endurance. The testing site consisted of two cones placed 100 yards apart. With the subject's first movement, the clock was started. One shuttle consisted of the subject running from the first cone to the second cone, touching the second cone and running back to the first cone, then touching the first cone and running to the second cone. The test was terminated when the subject passed the second cone. Five shuttles were required with a recovery period of 30 s between trials. This test was a criterion-referenced test. In order for the athlete to pass the test, he had to complete all five runs within the established time frame. The skill position players completed the run in under 60 s, and the power players completed the run in under 70 s. This test was performed on the football field at Waldo Stadium. The subject was allowed to run the test with a teammate who played the same position, skill or power.

Vertical Jump Test

The standing vertical jump test was used to measure leg power. The vertical jump was tested on the Vertec vertical testing apparatus (Sports Imports, Columbus, OH). The subject stood under the horizontal vanes then jumped and hit the highest vane, which swiveled to mark the jump height. The subject attempted to strike the highest vane he could reach during the flight phase of the vertical jump. The subjects were given three trials. However, if the subject hit a higher vane in the third trial, he continued to execute trials until he no longer was able to hit a higher vane. Once the subject could not reach a higher vane, the test was over. Each vane measured 0.5 in. This test was performed on the hardwood floor at Read Fieldhouse.

Research Design

The problem of this investigation was to compare strength and motor fitness performances for the following research variables: (a) 4 years of strength training—1992, 1993, 1994, and 1995—for all members of Western Michigan's football team; (b) the class of 1995 over the 4 years of their collegiate competition; and (c) positions, skill and power. Descriptive statistics, means, standard deviations, medians, and percentiles for each research variable were calculated for each strength test and each motor fitness test. Analyses of variances (ANOVA) and chi-squares (goodness of fit) were calculated to address the research hypotheses previously stated. The chi-square test was used to analyzed the criterion-referenced test, 300-yard shuttle run. The analyses consisted of the following:

1. An ANOVA or chi-square test was calculated for all strength tests and all motor fitness tests to determine differences among the 4 years.

2. An ANOVA or chi-square test was calculated to determine whether changes occurred across the 4 years for the class of 1995 for all strength tests and all motor fitness tests.

3. An ANOVA or chi-square test was calculated for each strength test and each motor fitness test to determine if changes occurred for the skill positions across the 4 years.

4. An ANOVA or chi-square test was calculated for each strength test and each motor fitness test to determine whether changes occurred for the power positions across the 4 years.

CHAPTER IV

RESULTS AND DISCUSSION

Introduction

The purpose of this study was to analyze the motor fitness and strength characteristics of the 1992 through 1995 Western Michigan University football teams. The study used male student athletes between the ages of 18 and 23 years from a Division I A football team from Western Michigan University, Kalamazoo. It was hypothesized that there would be no change in motor fitness and strength characteristics for the entire team over a 4-year period. It was also hypothesized that there would be an increase in the motor fitness and strength characteristics for the class of 1995 over a 4-year period. Analyses were performed on all of the team members over the 4-year period and on positions classified as skill and power. The results and discussion follow.

Results

Descriptive Results

Descriptive statistics were used to provide a profile of the strength and conditioning results of the entire Western Michigan University football team for years 1992 through 1995. This study also involved descriptive statistics for the class of 1995 for each of their respective years of eligibility. The skill and power positions were also evaluated for each of the 4 years.

The descriptive statistics that were analyzed for this study were the mean, standard deviation, and minimum and maximum scores for each year. The data were further explained as deciles and quartiles.

Entire Team

The following descriptive statistics are for the strength and motor fitness scores for all positions and all players over the 4-year period from 1992 through 1995. The statistics for all positions over all 4 years are presented in Table 2.

The mean scores for the bench press were similar for the 1993 team (322 lb), 1994 team (319 lb), 1995 team (300 lb), and 1992 team (297 lb). The standard deviation for the bench press was slightly larger in 1995 (64 lb) than for 1994 (61 lb), 1992 (59 lb), and 1993 (51 lb) teams. The minimum scores for the bench press were 184 lb, 163 lb, 165 lb, and 153 lb for 1992, 1993, 1994, and 1995, respectively. The maximum scores were 471 lb, 424 lb, 435 lb, and 435 lb for 1992, 1993, 1994, and 1995, respectively.

The mean scores for the hang clean were similar for the 1994 team (301 lb), 1995 team (298 lb), 1992 team (291 lb), and 1993 team (287 lb). The standard deviation scores for the hang clean varied with the 1992 team (44 lb) having the lowest value, followed by the 1994 (46 lb), 1995 (51 lb), 1993 (52 lb) teams. The minimum scores for the teams were 206 lb (1992), 135 lb (1993), 182 lb (1994), and 170 lb (1995). The maximum scores for the hang clean were 404 lb (1992), 404 lb (1993), 410 lb (1994), and 382 lb (1995).

The mean scores for the squat exercise were similar for all 4 years with the 1993 (543 lb) team having the highest value, followed by the 1992 (512 lb), 1994 (476 lb), and 1995 (471 lb) teams. The standard deviation for the 1993 (74 lb) team was the

Table 2

Strength and Motor Fitness Scores for All Positions

Year/ Test	Percentile											M	SD	Max	Min
	90	80	75	70	60	50	40	30	25	20	10				
1992															
Bench	375	348	336	326	314	294	284	265	255	241	213	297	59	471	184
Clean	357	324	312	308	300	286	276	271	265	263	218	291	44	404	206
Squat	620	592	533	530	530	520	500	464	440	440	440	512	72	670	350
20 yd	4.92	4.80	4.74	4.69	4.64	4.57	4.53	4.49	4.44	4.41	4.36	4.62	0.27	5.77	4.21
40 yd	5.51	5.28	5.22	5.19	5.07	4.96	4.88	4.80	4.73	4.68	4.51	5.00	0.38	6.11	3.72
VJ	31	29	29	28	27	25	24	23	23	22	21	26	4	37	16
1993															
Bench	388	370	353	341	331	324	318	300	295	286	254	322	51	424	163
Clean	356	330	325	316	300	280	276	256	253	235	218	287	52	404	135
Squat	600	600	600	600	596	530	530	530	530	500	400	543	74	700	350
20 yd	5.10	4.95	4.92	4.87	4.80	4.75	4.70	4.63	4.60	4.55	4.50	4.77	0.22	5.44	4.40
40 yd	5.38	5.16	5.12	5.05	4.91	4.83	4.79	4.67	4.65	4.58	4.50	4.89	0.33	5.90	4.39
VJ	32	31	30	30	29	27	26	25	25	24	22	27	4	38	20

Table 2—Continued

Year/ Test	Percentile											M	SD	Max	Min
	90	80	75	70	60	50	40	30	25	20	10				
1994															
Bench	401	373	366	353	339	329	313	286	274	261	230	319	61	435	165
Clean	345	335	329	324	324	306	295	273	271	265	240	301	46	410	182
Squat	557	527	512	506	500	482	469	435	429	414	381	476	67	660	364
20 yd	5.04	4.91	4.88	4.84	4.77	4.71	4.65	4.58	4.52	4.49	4.41	4.73	0.24	5.52	4.35
40 yd	5.38	5.22	5.15	5.10	4.95	4.89	4.82	4.75	4.70	4.69	4.54	4.91	0.32	5.93	4.30
VJ	30	29	28	27	26	25	23	22	22	21	19	25	4	34	16
1995															
Bench	382	353	341	335	324	300	283	272	256	241	210	300	64	435	153
Clean	363	340	335	326	325	300	296	271	265	265	222	298	51	382	170
Squat	547	516	512	506	491	482	467	435	429	427	371	471	63	653	324
20 yd	5.10	4.99	4.91	4.88	4.76	4.68	4.60	4.55	4.50	4.50	4.04	4.73	0.29	5.96	4.30
40 yd	5.48	5.23	5.16	5.09	5.10	4.97	4.90	4.80	4.79	4.76	4.56	4.99	0.32	5.80	4.30
VJ	31	29	29	28	28	26	26	24	24	23	22	27	4	35	18

highest value, followed by the 1992 (72 lb), 1994 (67 lb), and 1995 (63 lb) teams. The minimum scores, ranked from lowest to highest, for the squat exercise were 1992 (350 lb), 1993 (350 lb), 1994 (364 lb), and 1995 (324 lb) teams. The maximum squat scores for the 4 years ranked from highest to lowest, were 1993 (700 lb), 1992 (670 lb), 1994 (660 lb), and 1995 (653 lb) teams.

The mean score for the 20-yard shuttle run was 4.62 s for the 1992 team, 4.77 s for the 1993 team, 4.73 s for the 1994 team, and 4.73 s for the 1995 team. The standard deviation for the 1995 team was the highest, 0.29 s, followed by the 1992 team, 0.27 s, 1993 team 0.22 s, and the 1994 team, 0.24 s. The minimum scores ordered from smallest to largest, were 4.40 s for the 1993 team, 4.35 s for the 1994 team, 4.30 s for the 1995 team, and the 4.21 s for the 1992 team. The maximum scores ordered from highest to lowest, were 5.96 s for 1995, 5.77 s for 1992, 5.52 s for 1994, and 5.44 s for the 1993 teams.

The mean scores for the 40-yard dash were 5.00 s for 1992, 4.89 s for 1993, 4.91 for 1994, and 4.99 s for 1995. The standard deviations for the 40-yard dash were 0.38 s for 1992, 0.33 s for 1993, 0.32 s for 1994, and 0.32 s for the 1995 teams. The minimum scores for the 40-yard dash were 3.72 s (1992), 4.39 s (1993), 4.30 (1994), and 4.30 s (1995). The maximum scores for the 40-yard dash were 6.11 s in 1992, 5.90 s in 1993, 5.93 s in 1994, and 5.80 s in 1995.

The mean scores for the vertical jump across the 1992 through 1995 year period included 26 in., 27 in., 25 in., and 27 in., respectively. The standard deviation scores were 4 in. for all 4 years. The minimum score for the vertical jump was 16 in., 20 in., 16 in., and 18 in. for 1992, 1993, 1994, and 1995 teams, respectively. The maximum vertical jump scores for the Western Michigan football teams were 37 in. (1992), 38 in. (1993), 34 in. (1994), and 35 in. (1995).

Skill and Power Positions

The mean scores varied between the skill and power positions with the power positions demonstrating more strength and the skill positions dominating the motor fitness tests. The descriptive statistics for the skill and power positions are found in Table 3.

The mean scores for the bench press for the skill and power positions were 302 lb and 329 lb, respectively. The standard deviation for the skill position players was slightly higher, 61 lb, than for the power positions, 56 lb. The minimum score for the skill and power positions was 153 lb and 201 lb, respectively. The maximum score for the skill position players was 429 lb, which was lower than the maximum score for the power positions, 471 lb.

The mean score for the hang clean was 287 lb for the skill players and 313 lb for the power players. The standard deviation for the skill and power position players were 49 lb and 43 lb, respectively. The minimum score was lower for skill players, 135 lb, than for power players, 216 lb. The maximum score for the hang clean was slightly lower for the skill players, 404 lb, than for the power players, 410 lb.

The mean score for the squat was lower for the skill players, 490 lb than for the power players, 513 lb. The standard deviations for the squat were 77 lb and 63 lb for the skill and the power position players, respectively. The minimum squat scores for the skill and power position players were 324 lb and 380 lb, respectively. The maximum score for the skill position players was 700 lb, and the maximum score for the power position players was 670 lb.

There was a slight difference between the two categories for the 20-yard shuttle run. The mean score for the 20-yard shuttle run was 4.65 s for the skill players and

Table 3

Strength and Motor Fitness Scores for Skill Position Players and Power Position Players

Test	Percentile											M	SD	Max	Min
	90	80	75	70	60	50	40	30	25	20	10				
Bench															
Skill	376	347	341	335	324	312	290	272	261	247	218	302	61	429	153
Power	400	376	371	364	347	330	318	300	289	281	250	329	56	471	201
Clean															
Skill	347	329	324	320	300	288	276	265	257	247	218	287	49	404	135
Power	373	353	341	335	324	312	300	294	280	272	264	313	43	410	216
Squat															
Skill	600	547	530	530	512	500	482	440	432	418	375	490	77	700	324
Power	600	559	530	530	520	506	500	482	476	448	436	513	63	670	380
20 yd															
Skill	4.93	4.84	4.78	4.75	4.68	4.60	4.56	4.50	4.49	4.44	4.39	4.65	0.24	5.96	4.21
Power	5.24	5.10	5.06	4.99	4.91	4.88	4.80	4.74	4.69	4.66	4.59	4.89	0.24	5.52	4.44
40 yd															
Skill	5.17	5.06	5.00	4.96	4.89	4.82	4.77	4.70	4.65	4.60	4.50	4.84	0.26	5.60	3.72
Power	5.74	5.52	5.50	5.48	5.35	5.28	5.22	5.09	5.06	5.01	4.92	5.30	0.31	6.11	4.68
VJ															
Skill	32	30	30	29	28	27	26	25	24	24	23	27	4	38	18
Power	28	26	25	24	23	22	22	21	21	21	19	23	3	30	16

4.89 s and 4.89 s for the power players. The standard deviation for the 20-yard shuttle run was 0.24 s for both the skill players and the power players. The minimum score for the skill players was 4.21 s, and the minimum score for power players was 4.44 s. The maximum score for the skill players was 5.96 s, and the power players had a maximum score of 5.92 s.

The scores for the 40-yard dash varied greatly between the skill and power position players' means. The skill players had a mean score of 4.84 s, which was faster than the power players, 5.30 s. The standard deviations for the 40-yard dash was 0.26 s and 0.31 s for the skill and power positions, respectively. The minimum score for the skill players was 3.72 s, and the minimum for the power players was 4.68 s. The maximum for the skill players was 5.60 s, which was faster than the maximum time for the power players, 6.11 s.

The vertical jump scores for the skill players were greater than the vertical jump scores for the power players. The mean score for the skill players was 27 in., and it was 23 in. for the power players. The standard deviation scores for the skill and power position players in the vertical jump were 4 in. and 3 in., respectively. The minimum scores were 18 in. and 16 in. for the skill and power position players, respectively. The maximum score was 38 in. for the skill players and 30 in. for the power players.

Class of 1995

All of the scores for the class of 1995 showed a substantial improvement in the areas of physical strength and motor fitness abilities across the 4 years. The greatest improvements were found to be within the first 2 years of eligibility. The descriptive statistics for the class of 1995 can be found in Table 4.

The mean scores for the bench press were 301 lb, 331 lb, 354 lb, and 359 lb for

Table 4

Strength and Motor Fitness Scores for the Class of 1995 Over a Four-Year Period

Year/ Test	Percentile											M	SD	Max	Min
	90	80	75	70	60	50	40	30	25	20	10				
1992															
Bench	372	355	343	328	314	306	284	263	261	258	233	301	48	375	206
Clean	306	283	279	277	274	272	265	265	263	258	227	270	24	324	218
Squat	608	570	530	530	530	530	440	440	440	440	414	498	72	620	375
20 yd	4.79	4.67	4.65	4.62	4.57	4.56	4.52	4.51	4.51	4.41	4.33	4.56	0.16	4.95	4.29
40 yd	5.36	5.06	4.96	4.94	4.87	4.84	4.79	4.73	4.72	4.66	4.55	4.87	0.26	5.50	4.50
VJ	31	29	28	28	27	27	25	25	24	24	21	26	3	31	20
1993															
Bench	412	375	373	371	337	329	317	298	294	284	276	331	51	424	218
Clean	335	324	313	300	300	282	276	276	271	271	218	287	34	335	218
Squat	600	600	600	600	595	530	530	530	485	424	392	531	82	600	360
20 yd	5.10	4.92	4.89	4.85	4.80	4.77	4.74	4.64	4.60	4.55	4.50	4.77	0.23	5.44	4.41
40 yd	5.41	5.06	4.98	4.93	4.86	4.81	4.79	4.73	4.69	4.66	4.55	4.88	0.33	5.90	4.41
VJ	32	31	31	30	28	27	26	26	25	25	21	27	4	35	25

Table 4—Continued

Year/ Test	Percentile											M	SD	Max	Min
	90	80	75	70	60	50	40	30	25	20	10				
1994															
Bench	420	407	402	389	374	344	336	326	321	313	307	354	49	424	222
Clean	341	335	334	329	324	318	300	292	290	284	271	311	26	353	271
Squat	541	529	523	506	500	482	435	429	410	400	371	469	62	588	371
20 yd	5.08	4.93	4.89	4.82	4.76	4.72	4.61	4.55	4.49	4.48	4.38	4.71	0.24	5.20	4.35
40 yd	5.47	5.26	5.09	4.97	4.89	4.81	4.77	4.72	4.70	4.65	4.53	4.91	0.34	5.68	4.38
VJ	30	27	26	26	26	25	23	23	22	21	18	25	4	32	18
1995															
Bench	420	407	402	400	374	353	341	331	324	324	313	359	48	424	228
Clean	371	353	349	335	335	330	305	300	296	291	271	321	33	371	271
Squat	579	536	526	513	500	500	481	460	432	412	371	484	71	653	371
20 yd	5.22	4.97	4.85	4.75	4.70	4.64	4.57	4.53	4.52	4.46	4.41	4.70	0.27	5.27	4.32
40 yd	5.48	5.23	5.13	5.04	4.96	4.90	4.84	4.79	4.77	4.76	4.55	4.95	0.33	5.74	4.32
VJ	31	29	29	28	27	26	24	24	24	22	22	26	3	33	22

years 1992, 1993, 1994, and 1995, respectively. The standard deviations were 48 lb, 51 lb, 49 lb, and 48 lb, for years 1992, 1993, 1994, and 1995, respectively. The minimum scores for the bench press were 206 lb (1992), 218 lb (1993), 222 lb (1994), and 228 lb (1995). The maximum scores for the bench press were 375 lb in 1992, and 424 lb for years 1993, 1994, and 1995.

The mean scores for the hang clean were 270 lb for 1992, 287 lb for 1993, 311 lb for 1994, and 321 lb for 1995. The standard deviation over the 4 years were 24 lb for 1992, 34 lb for 1993, 26 lb for 1994, and 33 lb for 1995. The minimum scores for the hang clean were 218 lb (1992 and 1993), and 271 lb (1994 and 1995). The maximum scores for the hang clean were 324 lb (1992 and 1993), 353 lb in 1994, and 371 lb in 1995.

The mean scores for the squat were 498 lb for 1992, 531 lb for 1993, 469 lb for 1994, and 484 lb for 1995. The standard deviations for the squat were 72 lb, 82 lb, 62 lb, and 71 lb, for years 1992, 1993, 1994, and 1995, respectively. The minimum scores for the squat were 375 lb in 1992, 360 lb in 1993, 371 lb in 1994 and 1995. The maximum scores for the squat were 620 lb, 600 lb, 588 lb, and 653 lb, for the 4 consecutive years, respectively.

The mean scores for the 20-yard shuttle run were 4.56 s in 1992, 4.77 s in 1993, 4.71 s in 1994, and 4.70 s in 1995. The standard deviations for the 20-yard run included 0.16 s for 1992, 0.23 s for 1993, 0.24 s for 1994, and 0.27 for 1995. The minimum scores for the 20-yard shuttle run were 4.29 s in 1992, 4.41 s in 1993, 4.35 s in 1994, and 4.22 s in 1995. The maximum scores for the 20-yard run were 4.95 s in 1992, 5.44 s in 1993, 5.20 s in 1994, and 5.27 s in 1995.

The 40-yard dash scores for the class of 1995 showed an increase over the 4-year period. The mean scores for the 40-yard dash were 4.87 s in 1992, 4.88 s in 1993, 4.91 s

in 1994, and 4.95 s in 1995. The standard deviation scores were 0.26 s in 1992, 0.33 s in 1993, 0.34 s in 1994, and 0.33 s in 1995. The minimum scores for the 40-yard dash were 4.50 s in 1992, 4.41 s in 1993, 4.38 s in 1994, and 4.32 s in 1995. The maximum scores for the 40-yard dash were 5.50 s in 1992, 5.90 s in 1993, 5.68 s in 1994, and 5.74 s in 1995.

The mean scores for the vertical jump were 26 in., 27 in., 25 in., and 26 in. for years 1992, 1993, 1994, and 1995, respectively. The standard deviations over the 4-year period were 3 in., 4 in., 4 in., and 3 in., respectively. The minimum scores for the vertical jump were 20 in. in 1992, 21 in. in 1993, 18 in. in 1994, and 22 in. in 1995. The maximum scores for the vertical jump were 31 in. for 1992, 35 in. for 1993, 32 in. for 1994, and 33 in. for 1993.

ANOVAs

Two-way ANOVAs were calculated for the following descriptive variables: (a) bench press, (b) hang clean, (c) squat, (d) 40-yard dash, (e) 20-yard shuttle run, and (f) vertical jump. The main effects for each ANOVA were years with four levels (1992, 1993, 1994, and 1995) and group with two levels (skill and power). ANOVAs were run for all members of the football team and for members of the class of 1995.

Bench Press for the Entire Team

The results for the ANOVA for the bench press for all members of the Western Michigan University football team are as follows:

1. No significant differences were found among the years , F (3, 228) = 1.20, p = .312. The means for years 1992, 1993, 1994, and 1995 were 297 lb, 322 lb, 319 lb, and 300 lb, respectively.

2. A significant difference was found between the position groups, F (1, 228) = 4.41, p = .037. The means for the skill and power groups were 302 lb and 329 lb, respectively.

3. No significant interaction, effect years by group, was found, F (3, 228) = 0.49, p = .692.

The ANOVA summary table for the bench press is presented in Table 5.

Table 5

ANOVA Summary Table for the Bench Press

Source	*SS*	*df*	*MS*	*F*	*p*
Year (Y)	7323.75	3	2441.25	1.20	.312
Group (G)	8989.00	1	8989.00	4.41	.037*
Y × G	2977.42	3	992.47	0.49	.692
Residual	464871.12	228	2038.91		

*Significant at .05 level.

Hang Clean for the Entire Team

The results for the ANOVA for the hang clean for all members of the Western Michigan University football team are as follows:

1. No significant differences were found among the years, F (3, 228) = 2.33, p = .075. The means for years 1992, 1993, 1994, and 1995 were 291 lb, 287 lb, 301 lb, and 298 lb, respectively.

2. A significant difference was found between the groups, F (1, 228) = 13.67, p = .000. The means for the skill and power groups were 287 lb and 313 lb, respectively.

3. No significant interaction effect, years by group, was found, F (3, 228) = 0.78, p = .504.

The ANOVA summary table for the hang clean is presented in Table 6.

Table 6

ANOVA Summary Table for the Hang Clean

Source	*SS*	*df*	*MS*	*F*	*p*
Year (Y)	14439.76	3	4813.25	2.33	.075
Group (G)	28232.77	1	28232.77	13.67	.000*
Y × G	4855.77	3	1618.59	0.78	.504
Residual	470773.04	228	2064.80		

*Significant at .05 level.

Squat for the Entire Team

The results for the ANOVA for the squat for all members of the Western Michigan University football team are as follows:

1. Significant differences were found among the years, F (3, 228) = 9.36, p = .000. The means for the years 1992, 1993, 1994, and 1995 were 512 lb, 543 lb, 476 lb, and 471 lb, respectively.

2. A significant difference was found between the groups, F (1, 228) = 7.11, p = .008. The means for the skill and power groups were 490 lb and 513 lb, respectively.

3. No significant interaction effect, year by group, was found, F (3, 228) = 0.04, p = .988.

The ANOVA summary table for the squat is presented in Table 7.

Table 7

ANOVA Summary Table for the Squat

Source	*SS*	*df*	*MS*	*F*	*p*
Year (Y)	122365.04	3	40788.35	9.36	.000*
Group (G)	30989.70	1	30989.70	7.11	.008*
Y × G	559.58	3	186.53	0.04	.988
Residual	993620.51	228	4357.99		

*Significant at .05 level.

A Tukey HSD post hoc multiple comparison test was calculated to determine which of the paired years were significantly different. A table of differences between paired means for years is presented in Table 8. According to the Tukey HSD test for multiple comparisons, significant differences were found between the following years: (a) 1995 and 1992, the means were 471 lb and 512 lb, respectively; (b) 1995 and 1993, the means were 471 lb and 543 lb, respectively; (c) 1994 and 1992, the means were 476 lb and 512 lb, respectively; (d) 1994 and 1993, the means were 476 lb and 543 lb, respectively; and (e) 1992 and 1993, the means were 512 lb, and 543 lb respectively. All other pairwise comparisons were not significant.

20-Yard Shuttle Run for the Entire Team

The results for the ANOVA for the 20-yard shuttle run for all members of the Western Michigan University football team are as follows:

1. Significant differences were found among the years, F (3, 347) = 9.68, p =.000. The means for years 1992, 1993, 1994, and 1995 were 4.62 s, 4.77 s, 4.73 s,

Table 8

Mean Differences Between the Years for Squat for the Entire Team

		Ordered Means			
		1995	1993	1992	1993
Year	*M*	471	476	512	543
1995	471	___	5.00	41.00*	72.00*
1994	476		___	36.00*	67.00*
1992	512			___	31.00*
1993	543				___

Note. All numbers are in pounds.

* Significant at the .05 level.

and 4.73 s, respectively.

2. A significant difference was found between groups, $F(1, 347) = 84.54$, $p = .000$. The means for the skill and power groups were 4.65 s and 4.89 s, respectively.

3. No significant interaction effect, years by group, was found, $F(3, 347) = 1.64$, $p = .179$.

The ANOVA table for the 20-yard shuttle run is presented in Table 9.

A Tukey HSD post hoc multiple comparison test was calculated to determine which of the paired years were significantly different. A table of differences between paired means for years is presented in Table 10. According to the Tukey HSD test for multiple comparison, significant differences were found between the following years: (a) 1992 and 1994, the means were 4.62 s and 4.73 s, respectively; (b) 1992 and 1995,

the means were 4.62 s and 4.73 s, respectively; and (c) 1992 and 1993, the means were 4.62 s and 4.77 s, respectively. All other pairwise comparisons were not significant.

Table 9

ANOVA Summary Table for the 20-Yard Shuttle Run

Source	*SS*	*df*	*MS*	*F*	*p*
Year (Y)	1.53	3	0.51	9.68	.000*
Group (G)	4.46	1	4.46	84.54	.000*
Y × G	0.26	3	0.09	1.64	.179
Residual	18.30	347	0.05		

*Significant at .05 level.

40-Yard Dash for the Entire Team

The ANOVA results for the 40-yard dash for all members of the Western Michigan University football team are as follows:

1. No significant differences were found among the years, F (3, 347) = 1.84, p = .140. The means for years 1992, 1993, 1994, and 1995 were 5.00 s, 4.89 s, 4.91 s, and 4.99 s, respectively.

2. A significant difference was found between the groups, F (1, 347) = 174.97, p = .000. The means for the skill and power groups were 4.84 s and 5.30 s, respectively.

3. No significant interaction effect, years by group, was found, F (3, 347) = 1.64, p = .179.

The ANOVA summary table for the 40-yard dash is presented in Table 11.

Table 10

Mean Differences Between the Years for 20-Yard Shuttle Run for the Entire Team

		Ordered Means			
		1992	1994	1995	1993
Year	*M*	4.62	4.73	4.73	4.77
1992	4.62	___	0.11*	0.11*	0. 15*
1994	4.73		___	0.04	0.04
1995	4.73			___	0.04
1993	4.77				___

Note. All numbers are in seconds.

*Significant at the .05 level.

Table 11

ANOVA Summary Table for the 40-Yard Dash

Source	*SS*	*df*	*MS*	*F*	*p*
Year (Y)	0.42	3	0.14	1.84	.140
Group (G)	13.28	1	13.28	174.97	.000*
Y × G	0.37	3	0.13	1.64	.179
Residual	26.33	347	0.08		

*Significant at .05 level.

Vertical Jump for the Entire Team

The results for the ANOVA for the vertical jump for all members of the Western Michigan University football team are as follows:

1. No significant differences were found among the years, F (3, 347) = 2.49, p = .060. The means for years 1992, 1993, 1994, and 1995 were 26 in., 27 in., 25 in, and 27 in., respectively.

2. A significant difference was found between the groups, F (1, 347) = 79.37, p = .000. The means for the skill and power groups were 27 in. and 23 in., respectively.

3. No significant interaction effect, years by group, was found, F (3, 347) = 0.31, p = .821.

The ANOVA summary table for the vertical jump is presented in Table 12.

Table 12

ANOVA Summary Table for the Vertical Jump

Source	*SS*	*df*	*MS*	*F*	*p*
Year (Y)	95.45	3	31.82	2.49	.060
Group (G)	1014.35	1	1014.35	79.37	.000*
Y × G	11.72	3	3.91	0.31	.821
Residual	4434.77	347	12.78		

*Significant at .05 level.

Bench Press for the Class of 1995

The results for the ANOVA for the bench press for the class of 1995 members

of the Western Michigan University football team were as follows:

1. Significant differences were found among the years, F (3, 73) = 3.26, p = .026. The means for years 1992, 1993, 1994, and 1995 were 301 lb, 331 lb, 354 lb, and 359 lb, respectively.

2. No significant difference was found between the groups, F (1, 73) = 1.38, p = .244. The means for the skill and power groups were 333 lb and 257 lb, respectively.

3. No significant difference intervention effect years by group was found, F (3, 73) = .03, p = .993.

The ANOVA summary table for the bench press for the class of 1995 is presented in Table 13.

Table 13

ANOVA Summary Table for the Class of 1995 Bench Scores

Source	*SS*	*df*	*MS*	*F*	*p*
Year (Y)	24447.15	3	8149.05	3.26	.026*
Group (G)	3447.73	1	3447.73	1.38	.244
Y × G	224.29	3	74.76	0.03	.993
Residual	182561.66	73	2500.85		

*Significant at .05 level.

A Tukey HSD post hoc multiple comparison test was calculated to determine which of the paired years were significantly different. A table of differences between paired means for years is presented in Table 14. According to Tukey HSD test for multiple comparison, significant differences were found between the following years:

(a) 1992 and 1993, the means were 301 lb and 331 lb, respectively; (b) 1992 and 1994, the means were 301 lb and 331 lb, respectively; (c) 1992 and 1995, the means were 301 lb and 359 lb, respectively; (d) 1993 and 1994, the means were 331 lb and 354 lb, respectively, and (e) 1993 and 1995, the means were 331 lb and 358 lb, respectively. All other pairwise comparisons were not significant.

Table 14

Mean Differences Between the Years for Bench for the Class of 1995

		Ordered Means			
		1992	1993	1994	1995
Year	*M*	301	331	354	359
1992	301	___	30*	53*	58*
1993	331		___	23*	28*
1994	354			___	5
1995	359				___

Note. All numbers are in pounds.

*Significant at the .05 level.

Hang Clean for the Class of 1995

The results for the ANOVA for the hang clean for the class of 1995 members of the Western Michigan University football team are as follows:

1. Significant differences were found among the years, $F(3, 65) = 6.84$, $p = .000$. The means for years 1992, 1993, 1994, and 1995 were 270 lb, 287 lb, 311 lb, and

321 lb, respectively.

2. No significant difference was found between the groups, F (1, 65) = 0.16, p = .690. The means for the skill and power groups were 296 lb and 309 lb, respectively.

3. No significant interaction effect, years by group, was found, F (3, 65) = 0.16, p = .925.

The ANOVA summary table for the hang clean for the class of 1995 is presented in Table 15.

Table 15

ANOVA Summary Table for the Class of 1995 Hang Clean Scores

Source	*SS*	*df*	*MS*	*F*	*p*
Year (Y)	19244.57	3	6414.86	6.84	.000*
Group (G)	150.17	1	150.17	0.16	.690
Y × G	440.49	3	146.83	0.16	.925
Residual	60966.63	65	937.95		

*Significant at .05 level.

A Tukey HSD post hoc multiple comparison test was calculated to determine which of the paired years were significantly different. A table of differences between paired means for years is presented in Table 16. According to the Tukey HSD test for multiple comparisons, significant differences were found between the following years: (a) 1992 and 1994, the means were 270 lb and 311 lb, respectively; (b) 1992 and 1994, the means were 290 lb and 311 lb, respectively; (c) 1992 and 1995, the means were 270 lb and 321 lb respectively; (d) 1993 and 1994, the means were 287 lb and 311 lb,

respectively, and (e) 1993 and 1995, the means were 287 lb and 321 lb, respectively. All other pairwise comparisons were not significant.

Table 16

Mean Differences Between the Years for Hang Clean for the Class of 1995

		Ordered Means			
		1992	1993	1994	1995
Year	*M*	270	287	311	321
1992	270	___	17*	41*	51*
1993	287		___	24*	34*
1994	311			___	10
1995	321				___

Note. All numbers are in pounds.

*Significant at the .05 level.

Squat for the Class of 1995

The results for the ANOVA for the squat for the class of 1995 members of the Western Michigan University football team are as follows:

1. No significant differences were found among the years, F (3, 64) = 0.75, p = .528. The means for years 1992, 1993, 1994, and 1995 were 498 lb, 531 lb, 469 lb, and 484 lb, respectively.

2. No significant difference was found between the groups, F (1, 64) = 1.70, p = .197. The means for the skill and power groups were 487 lb and 515 lb, respectively.

3. No significant interaction effect, years by group, was found, F (3, 64) = 0.69, p = .562.

The ANOVA summary table for the squat for the class of 1995 is presented in Table 17.

Table 17

ANOVA Summary Table for the Class of 1995 Squat Scores

Source	*SS*	*df*	*MS*	*F*	*p*
Year (Y)	11013.47	3	3671.16	0.75	.528
Group (G)	8347.44	1	8347.44	1.70	.197
Y × G	10156.88	3	3385.63	0.69	.562
Residual	314659.53	64	4916.56		

20-Yard Shuttle Run for the Class of 1995

The ANOVA results for the 20-yard shuttle run for members for the class of 1995 from the Western Michigan University football team are as follows:

1. Significant differences were found among the years, F (3, 70) = 6.10, p = .001. The means for the years 1992, 1993, 1994, and 1995 were 4.56 s, 4.77 s, 4.71 s, and 4.70 s, respectively.

2. A significant difference was found between the groups, F (1, 70) = 43.96, p = .000. The means for the skill and power groups were 4.62 s and 4.92 s, respectively.

3. No significant interaction effect, years by groups, was found, F (3, 70) = 1.43, p = .241.

The ANOVA summary table for the 20-yard shuttle run for the class of 1995 is

presented in Table 18.

Table 18

ANOVA Summary Table for the Class of 1995 20-Yard Shuttle Run Scores

Source	*SS*	*df*	*MS*	*F*	*p*
Year (Y)	0.61	3	0.20	6.10	.001*
Group (G)	1.47	1	1.47	43.96	.000*
Y × G	0.14	3	0.05	1.43	.241
Residual	2.34	70	0.03		

*Significant at .05 level.

A Tukey HSD post hoc multiple comparison test was calculated to determine which of the paired years were significantly different. A table of differences between paired means for years is presented in Table 19. According to Tukey HSD multiple comparison, significant differences were found between the following years: (a) 1992 and 1995, the means were 4.56 s and 4.70 s, respectively; (b) 1992 and 1994, the means were 4.56 s and 4.71 s, respectively; and (c) 1992 and 1993, the means were 4.56 s and 4.77 s, respectively.

40-Yard Dash for the Class of 1995

The results for the ANOVA for the 40-yard dash for the class of 1995 members for the Western Michigan University football team are as follows:

1. Significant differences were found among the years, $F(3, 70) = 2.85$, $p = .043$. The means for years 1992, 1993, 1994, and 1995 were 4.87 s, 4.88 s, 4.91 s, and

Table 19

Mean Differences Between the Years for 20-Yard Shuttle Run for the Class of 1995

		Ordered Means			
		1992	1995	1994	1993
Year	*M*	4.56	4.70	4.71	4.77
1992	4.56	___	0.14*	0.15*	0.21*
1995	4.70		___	0.01	0.07
1994	4.71			___	0.06
1993	4.77				___

Note. All numbers are in seconds.

*Significant at the .05 level.

4.95 s, respectively.

2. A significant difference was found between the groups, F (1, 70) = 112.87, p = .000. The means for the skill and power groups were 4.77 s and 5.33 s, respectively.

3. No significant interaction effect, years by groups, was found, F (3, 70) = 1.90, p = .138.

The ANOVA summary table for the 40-yard dash for the class of 1995 is presented in Table 20.

A Tukey HSD post hoc multiple comparison test was calculated to determine which of the paired years significantly different. A table of differences between paired means for years is presented in Table 21. According to Tukey HSD test for multiple comparison a significant difference was found between 1992 and 1995, the means were

4.87 s and 4.95 s, respectively. All other pairwise comparisons were not significant.

Table 20

ANOVA Summary Table for the Class of 1995 40-Yard Dash Scores

Source	*SS*	*df*	*MS*	*F*	*p*
Year (Y)	0.33	3	0.11	2.85	.043*
Group (G)	4.34	1	4.34	112.87	.000*
Y × G	0.22	3	0.07	1.90	.138
Residual	2.69	70	0.04		

*Significant at .05 level.

Table 21

Mean Differences Between the Years for 40-Yard Dash for the Class of 1995

		Ordered Means			
		1992	1993	1994	1995
Year	*M*	4.87	4.88	4.91	4.95
1992	4.87	___	0.01	0.04	0.08*
1993	4.88		___	0.03	0.07
1994	4.91			___	0.04
1995	4.95				___

Note. All numbers are in seconds.

*Significant at the .05 level.

Vertical Jump for the Class of 1995

The results for the vertical jump for the class of 1995 members from the Western Michigan University football team are as follows:

1. No significant differences were found among the years, F (3, 71) = 1.26, p = .293. The means for years 1992, 1993, 1994, and 1995 were 26 in., 27 in., 25 in., and 26 in., respectively.

2. A significant difference was found between the groups, F (1, 73) = 30.95, p = .000. The means for the skill and power groups were both 27 in.

3. No significant interaction effect, years by group, was found, F (3, 71) = 0.69, p = .564.

The ANOVA summary table for the vertical jump is presented in Table 22.

Table 22

ANOVA Summary Table for the Class of 1995 Vertical Jump

Source	*SS*	*df*	*MS*	*F*	*p*
Year (Y)	32.39	3	10.80	1.26	.293
Group (G)	264.34	1	264.34	30.95	.000*
Y × G	17.57	3	5.86	0.69	.564
Residual	606.36	71	8.54		

*Significant at .05 level.

Chi-Square

Chi-square goodness of fit tests were calculated for the 300-yard shuttle run.

This calculation was conducted to determine if differences occurred across the 4 years with respect to the frequency of players who passed versus those who failed the 300-yard shuttle run test. The following chi-squares were calculated: (a) all players classified as skill position players, (b) all players classified as power position players, (c) the class of 1995's skill position players, and (d) the class of 1995's power position players. The chi-square results are as follows:

1. A significant chi-square was found for the skill position players for the entire team across the 4 years, χ^2 (3, N = 272) = 7.86, p = .05. The percentage of players passing the 300-yard shuttle run test for years 1992, 1993, 1994, and 1995 were 88%, 93%, 78%, and 92%, respectively.

2. No significant chi-square was found for the power position players for the entire team across the 4 years, χ^2 (3, N = 97) = 4.53, p = .21. The percentage of players passing the 300-yard shuttle run test for years 1992, 1993, 1994, and 1995 were 74%, 67%, 84%, and 92%, respectively.

3. A significant chi-square was found for the skill position players for the class of 1995 across the 4 years, χ^2 (3, N = 60) = 1.28, p = .73. The percentage of players passing the 300-yard shuttle run test for years 1992, 1993, 1994, and 1995 were 85%, 94%, 86%, and 93%, respectively.

4. A significant chi-square was found for the power position players for the class of 1995 across the 4 years, χ^2 (3, N = 19) = 0.80, p = .85. The percentage of players passing the 300-yard shuttle run for years 1992, 1993, 1994, and 1995 were 100%, 100%, 86%, and 86%, respectively.

The chi-square goodness of fit for the 300-yard shuttle run is presented in Table 23.

Table 23

Chi-Square Goodness of Fit for the 300-Yard Shuttle Run

Players	Position	χ^2	*df*	*p*
Entire Team	Skill	7.86	3	.05*
Entire Team	Power	4.53	3	.21
Class of 1995	Skill	1.28	3	.73*
Class of 1995	Power	0.80	3	.85*

*Significant at the .05 level.

Discussion

Entire Team and Class of 1995

The results for the entire team and the class of 1995 with respect to strength and motor fitness tests were as follows; the entire team showed little improvement over a 4-year period, but the class of 1995 showed more improvement over the same 4-year period. The following strength tests were not significantly different over the 4 years for the entire team: (a) bench press, and (b) hang clean. The following motor fitness scores were not significant over the 4 years for the entire team: (a) 40-yard dash, and the (b) vertical jump. The general lack of improvement with respect to the entire team can be attributed to the turnover rate of collegiate athletes. After a 4-year period all collegiate athletes lose their eligibility. In order to replace the veteran senior athletes unexperienced freshman athletes are added to the team. This turnover causes the team to remain relatively stagnant in respect to strength and motor fitness scores.

The class of 1995 improved significantly in strength and motor fitness scores

over their first 2 years of eligibility. The following strength tests were significantly different for the class of 1995 over 2 years: (a) bench press, and (b) hang clean. The following motor fitness scores were significantly different for the class of 1995 over years: (a) 20-yard shuttle run, (b) 40-yard dash, (c) vertical jump, and (d) the 300-yard shuttle run. The improvement that the class of 1995 experienced could be the result of being exposed to a structured strength and conditioning program during their most distinctive period of biological growth and motor skill development. Maximum strength is generally achieved at a time when the muscular cross-sectional area is the largest, which is between the ages of 20 and 30 years (Gabbard, 1992). Maximal motor performance potential closely parallels strength by reaching peak performance levels between 22 and 30 years of age (Gabbard, 1992). This fact can be supported by the observation that collegiate athletes are better than high school athletes and that few professional football athletes participate after the age of 30 years.

The majority of physical growth and development occurs during adolescence, ages 12 to 20 years, but the increases in motor performance during the adult years is primarily due to training, practice, and motivation (Payne & Isaacs, 1995). A structured strength and conditioning program exposes the athlete to sport-specific training through which they can practice the movements that are similar or related to the strength and motor fitness testing protocols. Such programs allow participants to gain strength and motor fitness skills so they are performing closer to their inherited ability (Schmidt, 1991). It is often said, "Athletes are born, not made" (Graham, 1994). This is true to a point. Coaches can improve skill, but not ability. Skill allows the athlete to work at a level closer to his true potential, never above his potential. Also motivation, working with teammates to better the individual and the team, is a factor that contributes to the individual's score in both strength and conditioning tests.

The changes in the strength and motor fitness scores over the 4 years for the Western Michigan Football teams may have been influenced by the fact that the head strength and conditioning coordinator changed after the 1993 football season. A change in the staff results in a difference in training philosophies and practices, which may also have resulted in the significant differences observed among the years. Over the 4-year period, more football athletes stayed in town over the summer off-season. This gave the strength and conditioning staff more influence over the conditioning regimen of the players.

Skill and Power Positions

The results for the skill and power position players across all 4 years are as follows: The skill position players indicated significantly higher scores in the 20-yard shuttle run, 40-yard dash, and vertical jump; and the power position players indicated significantly higher scores in the bench press, hang clean, and squat.

The results for the skill and power position players for the class of 1995 indicated that the power position players were significantly stronger than the skill position players in all the strength tests. However, the skill position players scored significantly better in the motor fitness scores. The differences in the scores between the two types of athletes are the result of training philosophies as well as genetic predisposition. The training protocols for the different position players simulate game situations. An emphasis is placed on speed and agility when training skill position players. By including more running and agility drills in each training session, the skill position players are required to move faster and thus the training is more specific to the demands of their positions. The power position players, training has more of an emphasis on strength and power. Strength and power are emphasized throughout the training sessions by extending the

rest periods between sets and allowing for maximal effort bouts of each exercise. For example, the power players take more time to rest during the power lifts than the skill players. Each player executes the same base lifts. For motor fitness development, the skill players work more with foot speed and agility. Examples include lateral movements, plyometrics, over-speed training, resistive work, and absolute speed (sprints). The power players' motor fitness development is comprised of drills that emphasize explosive power combined with movements executed in multiple directions. The power position players' practice sessions emphasize energy utilization from anabolic metabolism (Watts, 1996).

Genetics, inherited abilities, also play an important role in determining what position the athlete will play in regard to the game of football (Moreno, 1995). Typically, the larger individuals are expected to play the power positions, and the faster and often smaller, more agile athletes are placed in the skill positions. The separation between the two types of athletes is simply because it is easier to be more agile and fast in a small body, just as it is easier to be more stable and stronger in a larger body.

CHAPTER V

SUMMARY, FINDINGS, AND RECOMMENDATIONS

Summary

The purpose of this study was to determine the motor fitness and strength characteristics of the 1992 through 1995 Western Michigan University football teams. Specifically, the performances of the class of 1995 and various playing positions were compared to the performance of the entire team.

The subjects for this study were college male student athletes between the ages of 18 and 23 years. The participants were from the 1992 through 1995 Western Michigan University Division I A football teams. Strength tests and motor fitness tests that were measured for all 4 years, 1992 through 1995, were used in this study. The bench press, hang clean, and squat were measured using free weights, and results were expressed in pounds. The 40-yard dash, 20-yard shuttle run, and 300-yard shuttle run were measured in Read Fieldhouse, and results were expressed in seconds. The vertical jump results were expressed in inches.

The analyses consisted of the following:

1. An ANOVA or chi-square test was calculated to determine differences between the 4 years for all team members on all strength tests and on all motor fitness tests;

2. An ANOVA or chi-square test was calculated for the class of 1995 across all 4 years for all strength and all motor fitness tests;

3. An ANOVA or chi-square test was calculated for the skill positions across the 4 years for each strength test and motor fitness test;

4. An ANOVA or chi-square test was calculated for the power positions across the 4 years for each strength test and each motor fitness test.

Findings

Entire Team

Descriptive statistics for the entire team for 1992 were calculated for the bench press, hang clean, squat, 20-yard shuttle run, 40-yard dash, and vertical jump. The findings included the following:

1. The mean scores were 297 lb, 291 lb, and 512 lb, 4.62 s, 5.00 s, and 26 in., respectively.

2. The standard deviations were 59 lb, 44 lb, 72 lb, 0.27 s, 0.38 s, and 4 in., respectively.

3. The maximum scores were 471 lb, 404 lb, 670 lb, 5.77 s, 6.11 s, and 37 in., respectively

4. The minimum scores were 184 lb, 206 lb, 350 lb, 4.21 lb, 3.72 lb, and 16 in., respectively.

Descriptive statistics for the entire team for 1993 were calculated for the bench press, hang clean, squat, 20-yard shuttle run, 40-yard dash, and vertical jump. The findings included the following:

1. The mean scores were 322 lb, 287 lb, 543 lb, 4.77 s, 4.89 s, and 27 in., respectively.

2. The standard deviations were 51 lb, 52 lb, 74 lb, 0.22 s, 0.33 s, and 4 in.,

respectively.

3. The maximum scores were 424 lb, 404 lb, 700 lb, 5.44 s, 5.90 s, and 38 in., respectively.

4. The minimum scores were 163 lb, 135 lb, 350 lb, 4.40 s, 4.39 s, and 20 in., respectively.

Descriptive statistics for the entire team for 1994 were calculated for the bench press, hang clean, squat, 20-yard shuttle run, 40-yard dash, and vertical jump. The findings included:

1. The mean scores were 319 lb, 301 lb, 476 lb, 4.73 s, 4.91 s, and 25 in., respectively.

2. The standard deviations were 61 lb, 46 lb, 67 lb, 0.24 s, 0.32 s, and 4 in., respectively.

3. The maximum scores were 435 lb, 410 lb, 660 lb, 5.52 s, 5.93 s, and 34 in., respectively.

4. The minimum scores were 165 lb, 182 lb, 364 lb, 4.35 s, 4.30 s, and 16 in., respectively.

The descriptive statistics for the entire team for 1995 were calculated for the bench press, hang clean, squat, 20-yard shuttle run, 40-yard dash, and vertical jump. The findings included the following:

1. The mean scores were 300 lb, 298 lb, 471 lb, 4.73 s, 4.99 s, and 27 in., respectively.

2. The standard deviations were 64 lb, 51 lb, 63 lb, 0.29 s, 0.32 s, and 4 in., respectively.

3. The maximum scores were 435 lb, 382 lb, 653 lb, 5.96 s, 5.80 s, and 35 in., respectively.

4. The minimum scores were 153 lb, 170 lb, 324 lb, 4.30 s, 4.30 s, and 189 in., respectively.

Class of 1995

The descriptive statistics for the class of 1995 for the 1992 season were calculated for the bench press, hang clean, squat, 20-yard shuttle run, 40-yard dash, and vertical jump. The findings included the following:

1. The mean scores were 301 lb, 270 lb, 498 lb, 4.56 s, 4.87 s, and 26 in., respectively.

2. The standard deviations were 48 lb, 24 lb, 72 lb, 0.16 s, 0.26 s, and 3 in., respectively.

3. The maximum scores were 375 lb, 324 lb, 620 lb, 4.95 s, 5.50 s, and 31 in., respectively.

4. The minimum scores were 206 lb, 218 lb, 375 lb, 4.29 s, 4.50 s, and 20 in., respectively.

The descriptive statistics for the class of 1995 for the 1993 season were calculated for the bench press, hang clean, squat, 20-yard shuttle run, 40-yard dash, and vertical jump. The findings included the following:

1. The mean scores were 331 lb, 287 lb, 531 lb, 4.77 s, 4.88 s, and 27 in., respectively.

2. The standard deviations were 51 lb, 34 lb, 82 lb, 0.23 s, 0.33 s, and 4 in., respectively.

3. The maximum scores were 424 lb, 335 lb, 600 lb, 5.44 s, 5.90 s, and 35 in., respectively.

4. The minimum scores were 218 lb, 218 lb, 360 lb, 4.41 s, 4.41 s, 25 in.,

respectively.

The descriptive statistics for the class of 1995 for the 1994 season were calculated for the bench press, hang clean, squat, 20-yard shuttle run, 40-yard dash, and vertical jump. The findings included the following:

1. The mean scores were 354 lb, 311 lb, 469 lb, 4.71 s, 4.91 s, and 25 in., respectively.

2. The standard deviations were 49 lb, 26 lb, 62 lb, 0.24 s, 0.34 s, and 4 in., respectively.

3. The maximum scores were 424 lb, 353 lb, 588 lb, 5.20 s, 5.68 s, 32 in., respectively.

4. The minimum scores were 222 lb, 271 lb, 371 lb, 4.35 s, 4.38 s, and 18 in., respectively.

The descriptive statistics for the class of 1995 for the 1995 season were calculated for the bench press, hang clean, squat, 20-yard shuttle run, 40-yard dash, and vertical jump. The findings included the following:

1. The mean scores were 359 lb, 321 lb, 484 lb, 4.70 s, 4.95 s, and 26 in., respectively.

2. The standard deviations were 48 lb, 33 lb, 71 lb, 0.27 s, 0.33 s, and 3 in., respectively.

3. The maximum scores were 424 lb, 371 lb, 653 lb, 5.27 s, 5.74 s, and 33 in., respectively.

4. The minimum scores were 228 lb, 271 lb, 371 lb, 4.32 s, 4.32 s, and 22 in., respectively.

Skill and Power Positions

Descriptive statistics for the skill and power position players were calculated for the bench press. The findings included the following:

1. The mean scores were 302 lb and 329 lb, respectively.
2. The standard deviations were 61 lb and 56 lb, respectively.
3. The maximum scores were 429 lb and 471 lb, respectively.
4. The minimum scores were 153 lb and 201 lb, respectively.

Descriptive statistics were calculated for skill and power positions for the hang clean. The findings included the following:

1. The mean scores were 287 lb and 313 lb, respectively.
2. The standard deviations were 49 lb and 43 lb, respectively.
3. The maximum scores were 404 lb and 410 lb, respectively.
4. The minimum scores 135 lb and 216 lb, respectively.

Descriptive statistics were calculated for skill and power position players for the squat. The findings included the following:

1. The mean scores were 490 lb and 513 lb, respectively.
2. The standard deviations were 77 lb and 63 lb, respectively.
3. The maximum scores were 700 lb and 670 lb, respectively.
4. The minimum scores were 324 lb and 380 lb, respectively.

Descriptive statistics for skill and power position players were calculated for the 20-yard shuttle run. The findings included the following:

1. The mean scores were 4.65 s and 4.89 s, respectively.
2. The standard deviations were 0.24 s and 0.24 s, respectively.
3. The maximum scores were 5.96 s and 5.52 s, respectively.

4. The minimum scores were 4.21 s and 4.44 s, respectively.

Descriptive statistics were calculated for skill and power position players for the 40-yard dash. The findings included the following:

1. The mean scores were 4.84 s and 5.30 s, respectively.
2. The standard deviations were 0.26 s and 0.31 s, respectively.
3. The maximum scores were 5.60 s and 6.11 s, respectively.
4. The minimum scores were 3.72 s and 4.68 s, respectively.

Descriptive statistics for skill and power position players were calculated for the vertical jump. The findings included the following:

1. The mean scores were 27 in. and 23 in., respectively.
2. The standard deviations were 4 in. and 3 in., respectively.
3. The maximum scores were 38 in. and 30 in., respectively.
4. The minimum scores were 18 in. and 16 in., respectively.

Chi-Square

Chi-square goodness of fit tests were calculated for the 300-yard shuttle run. This calculation was completed to determine if differences occurred across 4 years with respect to the frequency of players who passed versus those who failed. The percentage of skill position players passing the 300-yard shuttle run for the entire team for years 1992, 1993, 1994, and 1995 were 88%, 93%, 78%, and 92%, respectively. The percentage of power position players passing the 300-yard shuttle run for the entire team for years 1992, 1993, 1994, and 1995 were 74%, 67%, 84%, and 92%, respectively. The percentage of skill position players passing the 300-yard shuttle run for the class of 1995 for years 1992, 1993, 1994, and 1995 were 85%, 94%, 86%, and 93%, respectively. The percentage of power position players passing the 300-yard shuttle run for the class of

1995 for years 1992, 1993, 1994, and 1995 were 100%, 100%, 86%, and 86%, respectively.

Conclusions

Entire Team and Class of 1995

Based on the results of this study, the entire team showed little improvement over a 4-year period. The general lack of improvement can be attributed to the turnover rate of collegiate athletes. This turnover causes the team to remain relatively stagnant with respect to strength and motor fitness scores.

The class of 1995 improved significantly over the first 2 years of eligibility. The improvement that the class of 1995 experienced was a result of being exposed to a structured strength and conditioning program, biological growth, and motor skill development.

The changes that the Western Michigan University football team experienced could have been the result of a change in the head strength and conditioning coordinator. These changes could have also been the result of having more football athletes staying in town for the summer, off-season training period.

Skill and Power Positions

The results from this study showed significantly higher scores for the skill position players in the 20-yard shuttle run, 40-yard dash, and vertical jump. The power position players scored higher in the bench press, squat, and hang clean. The differences between the two types of athletes are the result of two different training philosophies. The skill position players emphasize speed and agility in their training. The power

position players emphasize strength and power in their training. Genetics, inherited abilities, also plays an important role in determining what position an athlete will play. Typically, it is the larger individuals who play in the power positions and the small or more agile individuals who play the skill positions.

Recommendations

There is a need for further research that explores the development of football athletes during their collegiate careers. Further research could focus on variables that would produce more accurate strength and motor fitness development predictions. Two or more teams could be used to explore different strength and motor skill development in other strength and conditioning programs. Different divisions could be compared to chart the development of different skill levels. The positions could be broken down into actual playing positions to help football coaches further understand what athletic abilities are more evident in the different positions. The author postulates that the findings in this study are age and sport specific; if application is desired in older or different sport athletes, research must be conducted using these populations.

Appendix A

Human Subjects Institutional Review Board Approval

Human Subjects Institutional Review Board

Kalamazoo, Michigan 49008-38

WESTERN MICHIGAN UNIVERSITY

Date: 18 February 1997

To: Mary Dawson, Principal Investigator
Erick Schork, Student Investigator

From: Richard Wright, Chair

Re: HSIRB Project Number 97-01-18

This letter will serve as confirmation that your research project entitled "Analysis of the Motor Fitness and Strength of the 1992 Through 1995 Western Michigan University Football Teams" has been **approved** under the **exempt** category of review by the Human Subjects Institutional Review Board. The conditions and duration of this approval are specified in the Policies of Western Michigan University. You may now begin to implement the research as described in the application.

Please note that you may **only** conduct this research exactly in the form it was approved. You must seek specific board approval for any changes in this project. You must also seek reapproval if the project extends beyond the termination date noted below. In addition if there are any unanticipated adverse reactions or unanticipated events associated with the conduct of this research, you should immediately suspend the project and contact the Chair of the HSIRB for consultation.

The Board wishes you success in the pursuit of your research goals.

Approval Termination: 18 February 1998

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