AN ABSTRACT OF THE THESIS OF

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Title: The Effects of Two Six Week Isotonic Weight Training Methods on Leg Power, Strength and Speed of Football Players

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Purpose: The purpose of this study was to compare the effects of two isotonic weight training methods on leg power, leg strength and leg speed as measured by the Margaria-Kalamen and Orthotron tests and the 40-yard dash respectively.

Methods of Research: Twenty-seven football players were pre-tested for leg power, leg strength and leg speed. Fourteen subjects participated in three isotonic free weight exercises and thirteen subjects participated in three isotonic machine exercises. The subjects of each group completed five sets of five repetitions, one hour a day, two days per week for six weeks. Post-testing was administered to measure changes in leg power, leg strength and leg speed. The pre- and post-test scores from the Margaria-Kalamen, Orthotron, and 40-yard dash were utilized as the data which were analyzed by t-tests and analysis of variance with significance being accepted at the .05 level.

Conclusions: Based on data presented, it can be concluded that isotonic machine weight training and isotonic free weight training

methods using five sets of five repetitions, one hour a day, two days per week for six weeks produced no significant gains in mean leg power, leg strength and leg speed. Also, neither method of weight training proved to be significantly more effective than the other. This investigator's failure to induce a gain in strength, power and/or speed might have been from inadequate training stimulus and intensity.

THE EFFECTS OF TWO SIX WEEK ISOTONIC WEIGHT TRAINING METHODS ON LEG POWER, LEG STRENGTH AND LEG SPEED OF FOOTBALL PLAYERS

A Thesis

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Chapter 1

INTRODUCTION

This chapter is devoted to information concerning the relationship between the effects of two isotonic weight training methods on leg power, leg strength and leg speed of college football players. The statement of the problem, the null hypothesis, the assumptions, purpose, and significance of the study are discussed. Also included is the definition of terms.

Theoretical Formulation

In the past 25 years, strength and speed training have become an integral part of athletic training programs. Due to the recognition of the importance of strength and speed development in the preparation process for athletic participation. a wealth of information relating to the areas of weight training is available. However, there is minimal research that actually compares isotonic free weight training to isotonic machine weight training designed to improve leg power, leg strength and leg speed.

In all types of vigorous activities, the athlete's leg strength and speed are of particular importance to performance of the activity. The development of the athlete's strength and speed has been a major concern ever since the days of the Romans, when lifting of heavy objects was the chief means of obtaining overall strength for the physical combats of their day (Gaines, 1974). Athletes in activities such as football. basketball, soccer and rugby depend upon their legs for quick, powerful movement. For this reason, the different concepts of

improving the athlete's leg strength and leg speed have been of great interest to both the athlete and the coach in these particular sports. This study compared the effects of two types of isotonic resistance programs, free weights and machine weights, on development of leg power, leg strength and leg speed.

The Problem

Weight training has become a basic element in the training program of athletes for almost every sport. Much research has been conducted, investigating how various weight training methods can help an athlete gain muscular strength, power and speed. However, there has been little investigation of the effects of isotonic training with free weights as compared to the effects of isotonic training on a machine.

Is there a significant difference between the isotonic machine method and the isotonic free weight method of weight training in development of leg power and leg strength? Also, is there a significant difference between the isotonic machine method and the isotonic free weight method of weight training in development of leg speed? These questions have created a need for research in this area.

Statement of the Problem

Is there a significant difference in the scores of leg power, leg strength and leg speed for football players who participated in the machine method of weight training as compared to the scores of leg power, leg strength and leg speed for football players who participated in the free weight method of weight training?

Statement of the Hypothesis (Null Form)

There is no significant difference in leg strength and leg speed scores of subjects using the isotonic machine method of weight training (MM) as compared to the leg power, leg strength and leg speed scores of subjects using the isotonic free weight method of weight training (FW).

Stated symbolically, the null hypothesis was:

$$H_0 : \mu_{MM} = \mu_{FW}$$

while the alternate hypotheses were:

$$H_1 : \mu_{MM} < \mu_{FW}$$

$$H_2 : \mu_{MM} > \mu_{FW}$$

Assumptions of the Study

The following are basic assumptions made in the study:

1). Subjects tested put forth their best effort while performing all tests and exercises.

2). Subjects tested did not participate in any extra leg weight training exercises for the six week period.

3). The total work by all subjects in the study was comparable.

4). There was an increase in leg power, leg strength and leg speed from both methods of isotonic resistance training.

Purpose of the Study

The primary purpose of this investigation was to compare the effects of two methods of isotonic weight training on the development of leg power, leg strength and leg speed in college-aged male football

players. Twenty-seven subjects were divided into two groups performing the identical number of sets and repetitions. Group MM used an isotonic machine method. Group FW used an isotonic free weight method.

Significance of the Study

Leg power, leg strength and leg speed are important physical attributes in the modern game of football. For example, leg power and leg strength in linemen and leg speed in the receiver and defensive back positions are important factors for successful performance in these positions. Due to the relationship between these physical attributes and individual and team success, the best possible equipment and programs to increase leg power, leg strength and leg speed need to be determined. This study provides information that contributes to planning of an effective isotonic weight training program for improvement of leg strength , power and leg speed. The findings of this study will be valuable to coaches and administrators who are considering the purchase of weight training equipment specifically designed to develop leg musculature.

Definition of Terms

The following definition of terms applies in this study:

Dekan Timer. A timing device used in the Margaria-Kalamen test to time a subject's speed of ascent from the third step to the ninth step.

Isometric Exercise. A contraction of a muscle in which there is no change in the angle of involved joint(s) and little or no change in the length of the contracting muscle (Lamb, 1978).

Isotonic Exercise. A contraction of a muscle in which a constant resistance is moved through the full range of motion of the involved joint(s) (Lamb, 1978).

Leg Curl. A contraction of the hamstring muscles resulting in full flexion of the lower leg at the knee.

Leg Extension. A contraction of the quadricep muscles resulting in full extension of the lower leg at the knee.

Orthotron Machine. This testing device isolates the knee joint providing isokinetic resistance in both directions for safe, controlled rehabilitative exercise or testing.

Speed. The rate in time at which something moves, in this instance legs.

Strength. The force that a muscle or muscle group can exert against a resistance in one maximal effort (Fox, 1981).

Weight Training. The term weight training is in reference to a systematic plan of working weighted exercises for development of muscular strength and endurance. Specifically for this study, weight training was directed toward the development of strength of the lower body.

Limitations of the Study

The primary limitations of this study were that the physical activities of the subjects, aside from the leg power, strength and speed programs, were not controlled. The subjects engaged in a wide variety of physical activities during the time of the study. Such variation in exercise programs could affect the results of the study. However, if

anything, one would expect such activities to increase strength.

Methods and Procedures

The purpose of this study was to compare the effects of two methods of isotonic weight training on the development of leg strength and leg speed. The remainder of this chapter describes the methods and procedures to be used in the study. It includes information about population and sampling, equipment and facilities, design of the study, and data analysis.

Population and Sampling

The subjects for this study were randomly selected from the Emporia State University football team. The sample consisted of a group of 30 males varying in academic classification from second semester freshman to second semester juniors. Subjects involved in this study all had at least one year of uncontrolled and unsupervised weight training experience.

The isotonic free weight training group and the isotonic machine weight training group were formed by random sampling of the original 30 subjects prior to the pre-test. Initially both groups contained 15 subjects. Three subjects were released from this investigation due to injury leaving 13 free weight subjects and 14 machine weight subjects. Subjects in the investigation volunteered with the understanding that they could withdraw from the study at any time. Data were recorded on coded score sheets in such a manner that the information could not be identified with any specific subject, thereby assuring confidentiality.

Equipment and Facilities

The equipment used in this study consisted of one Continental adjustable weight and height scale, one 100-foot measuring tape, three American stopwatches, one Orthotron machine, two leg extension and leg curl machines, one MGI leg press machine, two free weight squat racks, one Dekan timer, and 1500 pounds of plate weight.

The entire weight training program was conducted in the weight-room facilities at Welch Stadium, located on the north side of Emporia State University campus. Adequate space was available to accomidate five lifters simultaneously.

Design and Procedure of the Study

Each subject was instructed by the experimenter concerning terminology, methods, techniques, and procedures to be followed for the duration of the weight training program. Before performing any pre-testing or weight training, each subject signed an informed consent form and were reminded of the importance of their full cooperation while being administered a test or performing an exercise.

Subjects were pre-tested the week of January 31 to February 4, 1983, on the Orthotron machine, Margaria-Kalamen power test, and forty-yard dash. The Orthotron test was performed in the training room at Emporia State University's Physical Education building. The Orthotron machine tested leg power and leg strength. Each participant was allowed two warm-up kicks before performing any experimental trials. The subjects then were given three kicks with each leg. The sum of the best score from each leg, expressed in foot-pounds, was used as the score to be analyzed. The exercise was performed at a

speed setting of "2" equalling 12^{0} per second (2 RPM).

The Margaria-Kalamen step test represents an objective measure of lower body power. Power is simply a product of strength and speed. Therefore, an increase in power is indicative of an improvement in muscular strength and/or speed. Subjects performed this test in the Physical Education building on a set of twelve steps located in the southeast part of the building. Before performing any trials each subject was weighted in his uniform of participation. Each of the subjects began by standing six meters in front of a series of twelve steps. On command, the subject ran as quickly as possible up the stairs, stepping on every third step. A Dekan timer started when the subject's foot struck the switchmat on the third step and stopped when his foot struck the switchmat on the ninth step. The elapsed time represented the time required to move the body weight the vertical distance between the third and ninth steps.

Power was calculated by the following:

$$\text{Power (kgm/sec)} = \frac{\text{Body Weight (kg)} \times \text{Vertical Distance (meters)}}{\text{Elapsed Time (sec)}}$$

The final test was the forty-yard dash representing a measure of leg speed. The test was administered with three individual timers, using the average time of all three stopwatches as a single score. Warm-ups were a one-quarter mile jog and five minutes of leg stretches. Each participant ran in lane two on the east side straight-away of Welch Stadium.

The first session of weight training was conducted on Monday, February 7, 1983. All subjects had been instructed by the experimenter in the proper methods and techniques for the resistance training that

they were to employ. During the six week period, a daily workout sheet was posted at each exercise station to inform the subjects of the pounds of weight to be lifted. Subjects exercised under the supervision of the experimenter and two Emporia State University football coaches. Each isotonic free weight subject performed exercises of leg squats, leg curls, and leg extensions with free weights. Each isotonic machine subject performed exercises on the leg press, leg curl, and leg extension machines. Two days per week were spent in the weight training sessions. The subjects completed five sets of five repetitions at each station. The weight was determined according to the subject's ability at five RM (repetition maximum). When the subject was able to handle the weight load at five repetitions of five sets, the subject's workload was increased five to ten pounds. Upon conclusion of the sixth week, post-testing was administered March 21 through March 25, 1983.

Data Analysis

The data collected in this study were analyzed to compare the effects of the machine weight training method and the free weight training method for the development of leg strength and leg speed. Analysis of leg strength was based on results made in the test performance of the subject's Margaria-Kalamen power test and test performance on the Orthotron machine. The forty-yard dash performance was used for the analysis of speed.

The scores from the post-test were utilized to compute the means and significant difference between the means. The *t*-test for independent samples was used to determine if the obtained information had significant difference between the pre- and post-test (differences)

scores of both isotonic groups. Analysis of variance (ANOVA) was used also to test for significant differences between the means of the isotonic groups which contained different sample sizes.

Chapter 2

REVIEW OF RELATED LITERATURE

The value of weight training for development of muscular strength was initially demonstrated by both Capen and Chui (1956, 1950). Chui (1950) developed a study to determine the effects of systematic free weight training on strength. The control group was 29 students who were members of a conditioning class. Forty members of the experimental group exercised with free weights. Each group participated in three exercises, three days a week for six weeks. Results from this experiment showed significant improvement in strength through systematic free weight training.

Four different ten week isotonic weight training programs were observed by Capen (1956) to determine which was superior in regard to strength development. For each exercise, individuals in Group I were required to select the heaviest weight which they could perform a maximum number of eight repetitions. Each subject worked toward a goal of 15 repetition at the starting weight. Upon achieving their goal, a new eight-repetition maximum was determined and further exercise was undertaken to again increase strength and the number of repetitions.

Group II began the experiment in the same manner as Group I, however for each exercise, subjects selected the heaviest weight which they could perform a maximum number of five repetitions. Upon exercising, an increase in strength enabled subjects to achieve six repetitions and a new five-repetition maximum was determined.

The subjects in Group III selected the heaviest weight which they could perform a maximum number of five repetitions. The subjects then performed three sets with this selected weight, performing as many repetitions as possible in the second and third sets.

Group IV subjects selected the heaviest weight which they could lift only once. After executing the exercise with the maximum weight, the weight was decreased slightly for the second set and the subject performed as many repetitions as possible. Results indicated that the gain in strength from each of the four groups was almost equal.

In Payne's (1968) study the purpose was to determine which eight week exercise program, either isotonic or isometric, was the most effective in improving strength and speed of movement. Subjects used in this study were 72 eighth grade girls, ages 12 to 13 years, enrolled in three physical education classes. Group I was assigned as the experimental isotonic group performing an average of six exercises each period. Group II was the control group which played games during the experimental period. Group III was the experimental isometric group performing an average of six exercises each period with isometric contractions that were held eight seconds. Arm and shoulder girdle strength were measured by the vertical pull, push and pull hand dynamometer, and the bent arm hang. Speed of the dominant arm was measured by the timing of ten round trip horizontal arm movements between two boards standing upright two feet apart. The score was recorded to the nearest one-tenth of a second. The results of the training program indicated an increase in the mean performance of strength which was related to the increase of speed in all three groups with the isotonic group being superior.

Hooks (1962) points out that isotonic weight training can possibly improve strength and speed simultaneously. A six week weight training program that overloads the muscle with enough weight to ensure strength gains, and at the same time enables the muscles to contract successfully with a burst of speed, will produce increases in strength and speed. Hooks conducted experiments at Wake Forest University with boys from all skill levels, ranging from groups of the very poorest physically fit subjects in the freshman physical education classes to the most advanced varsity athletes. Results from this study indicate that there is a close relationship between increased muscle speed and participation in a concentrated weight training program.

In one experiment, a class of 27 of the poorest students was tested in the sixty-yard dash, after which the subjects participated in a supervised isotonic weight training program for three days a week for six weeks. During this time they were encouraged to do no running. At the end of the six week period, they were retested on the sixty-yard dash. The difference between the mean score for the second test was a decrease in time of 0.28 seconds resulting in an increase in speed.

In another experiment by Hooks, the varsity football team did not register the same dramatic results, but did show an improvement in speed. The subjects were pre-tested in the forty-yard dash representing a measure of speed. They then participated in a six week program of isotonic weight training, after which they were post-tested on the dash. The differences between the pre- and post-test means was a decrease of 0.22 seconds.

Reade and Alley (1962) undertook an experiment to determine the effects of isotonic weight training upon the starting speed of twenty-two football players. After two weeks of early fall conditioning practice, the players were tested on how rapidly they could charge one yard from a four point stance and hit a blocking dummy with either shoulder. This maneuever was timed electrically. Immediately following the first testing. groups were divided at random into a control group and a experimental group. The experimental group took part in football plus a short weight training program three times per week for six weeks. At the completion of the football season the subjects were retested. Analysis of data showed that weight trainers increased starting times significantly as compared to the non-lifters.

Masley, Hairabedian, and Donaldson (1953) attempted to determine whether isotonic weight training was accompanied by an increase in muscular coordination and speed of movement. Group I subjects engaged in an eight week isotonic weight training program stressing moderate poundage and repetitions. Group II engaged in learning skills of volleyball. From the data they presented, it appears that muscular coordination and speed of movement are actually improved after a period of isotonic weight training.

Fishbain (1960) studied the effects of a isotonic weight training program upon performance in the 35-yard dash. An experimental group of twelve high school boys participated in a program involving six weight training exercises, four days a week for a nine week period. All subjects were tested at the beginning and the end of the experiment. The results showed the experimental group had a significant decrease in times for the 35-yard dash.

Clarke (1961) investigated the possibility of increased speed due to strength development. In this study arm strength and speed in a lateral adductive arm movement were measured in 62 college men and retested ten weeks later. During this interval, half remained inactive in order to provide a control group. The isotonic group exercised three days a week using three different arm exercises. The results showed the average speed and strength of the training group improved significantly. In the arm movement studied, individual differences in the amount of change in strength had a low but significant correlation with individual changes in maximal speed of movement.

Costill and his associates (1968) designed a study to demonstrate the relationship which exists among selected tests of explosive leg power and leg strength. Power is simply a product of strength and speed, therefore, an increase in power is indicative of an improvement in muscular strength and/or speed. The explosive leg strength tests employed were the vertical jump, standing broad jump, forty-yard dash and the squatweight lift. The Margaria test of maximal anaerobic power and maximal vertical velocity was used to measure the power production of the legs. Subjects were 76 members of a physical conditioning program at Ball State University. Results showed that speed in the forty-yard dash was related to vertical velocity and that power, as measured by the Margaria, was related to both strength and speed.

Berger's (1962) data furnished support for the effectiveness of various numbers of repetitions in isotonic weight training. Data indicate that fewer than 10 RM may be most effective. Four, five or six provide maximal results in terms of strength gain.

deVries (1980) sets the optimal number of workouts per week at

between three and five, depending on the amount of vigorous activity a given individual may be indulging in beyond the weight training program. This does not mean that five or more days per week will not give additional benefits, but simply that, for health purposes, one gets the best return for the amount of time invested.

Fox (1979) shows the results of a study using isotonic programs that varied widely in sets and RM loads. Significant isotonic strength gains were made in programs consisting of as few as one set at 2 RM loads and as many as 5 sets at 10RM loads. Provided the frequency of exercise is within the proper bounds just cited, significant strength gains can be expected to occur following weight training programs of six weeks or longer.

Fox (1981) did further research concerning the optimum number of sets and repetitions that would most effectively increase strength. These studies employed programs with a training frequency of three days per week over a duration of eight to twelve weeks. It can be seen that the greatest improvement in strength is obtained from three sets, each with a 6 RM load. Generally it can be said that the optimal number of repetitions maximum lies somewhere between three and nine. When different numbers of sets are combined with different RM loads, several equivalent programs for strength can be developed.

After carefully examining the related literature, it was concluded that a relationship exists between isotonic resistance exercises in the form of weight training and increased muscular strength and speed. However, the wide variety of sets and weight repetitions, number of days per week and total number of weeks never gave a single specified combination of set of repetitions, days or weeks which gave

maximum results. Certainly, the Hooks (1962), Fishbain (1960), Clarke (1961), and Chui (1950) studies utilized isotonic free weights suggesting some type of relationship between six to ten weeks of weight training and an increase in strength and speed. Also studies by Fox (1962, 1979) and Berger (1962) provided weight training programs which utilized several different sets and repetitions.

Chapter 3

ANALYSIS OF DATA

This chapter contains the analysis of data for the Margaria-Kalamen, Orthotron and Forty Yard Dash tests for both groups. The statistical procedures used for analysis included the t-test and analysis of variance.

Margaria-Kalamen Test

The Margaria-Kalamen test was administered to the machine and free weight exercise groups prior to and following a six week isotonic weight training program. The mean power scores of the pre-tests for each group were subjected to the t-test to determine if a significant difference existed at the .05 level.

Analysis of Margaria-Kalamen Data

The machine group had a mean of 193.23 kilograms per second (kgm/sec.) for the pre-test with a standard deviation of 20.10 kgm/sec. The free weight exercise group had a pre-test mean of 195.45 kgm/sec. and a standard deviation of 13.29 kgm/sec. For the post-test measures, the machine exercise group had a mean of 197.36 kgm/sec. and standard deviation of 16.08 kgm/sec., while the free weight exercise group had a mean of 196.34 kgm/sec. with a standard deviation of 12.21 kgm/sec.
An analysis of variance was computed with no significant difference (Appendix F).

Table 1

Means and Standard Deviations on Machine and Free Weight Exercise Groups on the Margaria-Kalamen

Source	N	Mean (kgm/sec)	Standard Deviation (kgm/sec)
Machine Group:			
Pre-test	14	193.23	20.10
Post-test	14	197.36	16.08
Free Weight Group:			
Pre-test	13	195.45	13.29
Post-test	13	196.34	12.21

The *t*-test for independent samples was calculated for the difference between the pre- and post-test scores. The mean for the difference between the pre- and post-test scores for the machine exercise group was 4.279 kgm/sec with a standard deviation of 7.959 kgm/sec. For the free weight exercise group the mean difference was 1.115 kgm/sec with a standard deviation of 11.302 kgm/sec.

Table 2

t-table for Margaria-Kalamen scores for Machine and Free Weight Groups

Source	df	Mean Differences (kgm/sec)	Standard Deviation (kgm/sec)	*t*
Machine Group	25	4.279	7.959	0.846
Free Weight Group	25	1.115	11.302	

For the statistical data to be significant at the .05 level, a t-test value $\geq$ 2.05 was necessary using 25 degrees of freedom. A t-test value of 0.846 was calculated and was not significant at the .05 level.

Orthotron Test

The Orthotron test was administered to the machine and free weight exercise groups prior to and following a six week isotonic weight training program. The mean score of the pre-test for each group was subjected to the t-test to determine if a significant difference existed at the .05 level.

Analysis of Orthotron Data

The machine exercise group had a mean of 926.79 foot-pounds for the pre-test with a standard deviation of 118.95 foot-pounds. The free weight exercise group had a mean of 905.38 foot-pounds on the pre-test and a standard deviation of 109.97 foot-pounds. For the post-test measures the machine exercise group had a mean of 976.43 foot-pounds and a standard deviation of 106.20 foot-pounds, while the free weight exercise group had a mean of 935.00 foot-pounds with a standard deviation of 91.63 foot-pounds.

An analysis of variance was computed with no significant difference (Appendix F).

Table 3

Means and Standard Deviation on Machine and Free Weight Exercise Group on the Orthotron Machine

Source	N	Mean (foot-pounds)	Standard Deviation (foot-pounds)
Machine Group:			
Pre-test	14	926.79	118.95
Post-test	14	976.43	106.20
Free Weight Group:			
Pre-test	13	905.38	109.97
Post-test	13	935.00	91.63

The *t*-test for independent samples was calculated for the differences between the pre- and post-test scores. The mean difference between the pre- and post-test scores for the machine exercise group was 48.929 foot-pounds with a standard deviation of 66.338 foot-pounds. For the free weight exercise group, the mean difference was 21.923 foot-pounds with a standard deviation of 102.724 foot-pounds.

Table 4

t-table for Orthotron Scores for Machine and Free Weight Groups

Source	df	Mean Differences (foot-pounds)	Standard Deviation (foot-pounds)	*t*
Machine Group	25	48.929	66.338	0.818
Free Weight Group	25	21.923	102.724	

For the statistical data to be significant at the .05 level, a data t-test value $\geq$ 2.05 was necessary using 25 degrees of freedom. A t-test value of 0.818 was calculated and was not significant at the .05 level.

Forty Yard Dash

The forty yard dash was administered to the machine and free weight exercise group prior to and following a six week isotonic weight training program. The mean score time of the pre-test for each group was subjected to the t-test to determine if a significant difference existed at the .05 level.

Analysis of Forty Yard Dash Data

The machine exercise group had a mean of 5.14 seconds for the pre-test with a standard deviation of 0.23 seconds. The free weight exercise group had a mean of 5.06 seconds on the pre-test and a standard deviation of 0.25 seconds. For the post-test measures the machine exercise group had a mean of 5.14 seconds and a standard deviation of 0.30 seconds, while the free weight exercise group had a mean of 5.02 seconds with a standard deviation of 0.33 seconds. An analysis of variance was computed with no significant difference (Appendix F).

Table 5

Means and Standard Deviation on Machine and Free Weight Exercise Groups on the 40 Yard Dash

Source	N	Mean (seconds)	Standard Deviation (seconds)
Machine Group:			
Pre-test	14	5.14	0.23
Post-test	14	5.14	0.30
Free Weight Group:			
Pre-test	13	5.06	0.25
Post-test	13	5.02	0.33

The *t*-test for independent samples was calculated for the difference between the pre- and post-test scores. The mean difference between the pre- and post-test scores for the machine exercise group was slightly faster (-0.001 seconds) with a standard deviation of 0.115 seconds. For the free weight exercise group the mean difference was slightly slower (0.028 seconds) with a standard deviation of 0.169 seconds.

Table 6

t-table for 40 Yard Dash Scores for Machine and Free Weight Groups

Source	df	Mean Differences (seconds)	Standard Deviations (seconds)	*t*
Machine Group	25	-0.001	0.115	-0.540
Free Weight Group	25	0.028	0.169	

For the statistical data to be significant at the .05 level a data t-test value $\geq$ 2.05 was necessary using 25 degrees of freedom. A t-test value of -0.540 was calculated and was not significant at the .05 level.

Analysis of Variance

Analysis of variance for both pre- and post-test scores was used also to see if there was a significant difference between the pre- and post-test measures. No significant difference was found between the two groups for their pre- and post-test scores (Appendix F).

Chapter 4

SUMMARY, CONCLUSIONS, AND RECOMMENDATIONS

This study was completed to determine if there was asignificant difference in the effect of two six week isotonic weight training programs on test data of college football players as measured by the Margaria-Kalamen, Orthotron and forty-yard dash tests. Data were collected and analyzed as previously described in Chapters One and Three.

Summary

The purpose of this study was to compare the effects on leg power, leg strength and leg speed of an isotonic machine weight training program to the effects on leg power, leg strength and leg speed of an isotonic free weight program. Such knowledge is valuable to physical educators and coaches who are interested in establishing weight training programs for development of leg strength and leg speed. It would be helpful also to administrators and coaches considering the purchase of weight training equipment.

Prior to the isotonic weight training programs, the group of 27 college football players was given the previously described tests for strength, power and speed. Each experimental group trained with their isotonic weight training program for one hour per day, two days a week for six weeks. Each isotonic free weight subject performed five sets of five repetitions of leg squats, leg curls and leg extensions using free weights. Each isotonic machine subject performed identical sets

and repetitions on the leg press, leg curl and leg extension machines. At completion of the weight training period, the subjects were administered the post-test for strength, power and speed.

Analysis of variance showed that neither the machine weight training group nor the free weight training group made significant changes in leg power, leg strength or leg speed of these subjects. No significant difference existed between the machine weight training group and free weight training group on the Margaria-Kalamen pre- and post-tests.

Analysis of variance showed that neither the machine weight training group nor the free weight training group made significant changes in leg power or leg strength. There was no significant difference on the machine weight training or free weight training groups.

Analysis of variance showed neither isotonic group made any significant changes in leg speed between the pre- and post-test. Finally, neither the machine weight training group nor free weight training group showed a significant difference on the pre- and post-tests on the forty-yard dash.

In this study neither isotonic machine weight training or isotonic free weight training was effective in improving leg power, leg strength or leg speed. Possibly a result of participating in approximately one year of uncontrolled and unsupervised weight training caused this effect. Possibly subjects who participated in previous weight training, were currently at their peak level of weight resistance when the experimental training began, therefore, one would expect maximum exertion at peak times to remain at the same level. Neither group produced significantly greater improvement than the other. Both groups might have had significant changes in leg power, leg strength and leg speed had the sets,

repetitions and number of exercises been increased to provide greater resistance for a longer period of time (Hooks, 1962; Payne, 1968). Also, increasing the percent of new weight added at each exercise station could effect changes in leg strength, leg power and speed (Capen, 1956).

Conclusions

Within the limitations of this study, the following conclusions appear to be justified. In accordance to the weight training guidelines that were established, neither isotonic group showed any significant gains in power, strength and speed. This study utilized five sets and five repetitions for both the isotonic weight training programs. It was suggested by Fox (1979) that five sets of 2 to 10 RM is a sufficient load and that strength gains should be expected to occur with six weeks or longer. According to Berger (1962) the value of varying number of repetitions is vital to strength improvements in his study of optimal repetition. Berger found that four, five or six repetitions would provide significant results if done at maximum repetition. This investigator's failure to induce a gain in power, strength and/or speed might have been from inadequate training stimulus and intensity.

It was concluded that these isotonic machine weight training and isotonic free weight training programs did not significantly improve leg strength in college football players as measured by the Margaria-Kalamen and Orthotron tests. Also these isotonic machine weight training and isotonic free weight training programs did not significantly change the leg speed of college football players as measured by the forty-yard dash test. In addition, there was no significant

differences in effects between the two isotonic weight training programs.

Recommendations

This section offers suggestions for the direction of further research that relates to the area of interest in this study. Also, some factors that became items of concern during this study are identified.

It is recommended that a similar study be undertaken in which the experimental time is extended to ten weeks as Clarke (1961) did in his study. It is also recommended the subjects weight train three times a week as did the subjects of Hooks (1962) and Reade and Alley (1962). Perhaps if more sets and repetitions were employed the results would reflect a more positive change. Before one can compare the effects of two methods, it is necessary to assure that the programs employed are adequate for producing an increase in strength and power as would be expected.

Another area of concern related to the lack of control of the subjects' extra-curricular activities outside of the weight training program. Further studies of the effects of strength training programs should include control of the subjects' entire extra-curricular activities.

If all of the above controls were available, a study comparing the effects of various weight training methods could produce results useful in planning programs designed to enchance leg muscle strength, power and speed efficiently and effectively. Athletes could then strengthen the appropriate muscles by using the best equipment and training technique for that particular muscle or muscle group.

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APPENDIX A

Informed Consent Form

INFORMED

CONSENT FORM

As a subject of this study I fully understand the procedures and risks involved in participating. I understand this experiment will occupy eight consecutive weeks involving one week of pre-testing, six weeks of exercising and one week of post-testing.

The exercise sessions will be performed a minimum of two days a week with five sets of five repetitions on the squat rack, leg extension and leg curl each session.

The pre- and post-testing sessions will consist of flexion and extension tests on the Orthotron machine, three forty-yard dash sprints and three trials at the Margaria-Kalamen-Step test.

I am volunteering for this experiment fully understanding that I may withdraw from participation at any time.

I release all information and data gathered from this experiment to be used in the said study.

Thus, I hereby release the State of Kansas, Emporia State University, Physical Education, and their employees from all liability for any injury incurred through participating in this study.

Name	Date

INFORMED

CONSENT FORM

As a subject of this study I fully understand the procedures and risks involved in participating. I understand this experiment will occupy eight consecutive weeks involving one week of pre-testing, six weeks of exercising and one week of post-testing.

The exercise sessions will be performed a minimum of two days a week with five sets of five repetitions on the leg press, leg extension and leg curl each session.

The pre- and post-testing sessions will consist of flexion and extension tests on the Orthotron machine, three forty-yard dash sprints and three trials at the Margaria-Kalamen-Step test.

I am volunteering for this experiment fully understanding that I may withdraw from participation at any time.

I release all information and data gathered from this experiment to be used in the said study.

Thus, I hereby release the State of Kansas, Emporia State University, Physical Education, and their employees from all liability for any injury incurred through participating in this study.

NAME	DATE

APPENDIX B

Workout Report Form

Name _____

Group _____

EXERCISE	LBS	REPS	LBS	REPS	LBS	REPS	LBS	REPS	LBS	REPS
MACHINE WEIGHT										
LEG EXT.										
LEG CURL										

Name _____

Group _____

EXERCISE	LBS	REPS	LBS	REPS	LBS	REPS	LBS	REPS	LBS	REPS
FREE WEIGHT										
LEG EXT.										
LEG CURL										

APPENDIX C

Margaria - Kalamen
Step Test

ISOTONIC MACHINE WEIGHT SUBJECTS

Margaria-Kalamen: Raw Data

Time (sec.)

Subject #		Weight	Trial 1	Trial 2	Trial 3	Trial 4	Trial 5	Trial 6
01	Pre	104.7(kg)	0.545	0.541	0.546	0.535	0.530	0.532
	Post	106.1(kg)	0.535	0.528	0.529	0.521	0.525	0.530
02	Pre	79.8(kg)	0.457	0.459	0.442	0.447	0.445	0.451
	Post	81.6(kg)	0.467	0.471	0.458	0.457	0.460	0.453
03	Pre	75.7(kg)	0.467	0.529	0.460	0.466	0.458	0.462
	Post	76.2(kg)	0.444	0.438	0.451	0.447	0.451	0.440
04	Pre	101.1(kg)	0.602	0.585	0.578	0.581	0.578	0.571
	Post	102.0(kg)	0.565	0.562	0.541	0.548	0.550	0.547
05	Pre	95.2(kg)	0.528	0.518	0.528	0.530	0.520	0.525
	Post	95.7(kg)	0.500	0.513	0.520	0.503	0.498	0.509
06	Pre	106.1(kg)	0.578	0.570	0.561	0.563	0.565	0.582
	Post	104.3(kg)	0.529	0.536	0.525	0.525	0.520	0.531
07	Pre	80.7(kg)	0.513	0.523	0.518	0.530	0.527	0.527
	Post	83.0(kg)	0.479	0.500	0.503	0.497	0.492	0.502
08	Pre	98.8(kg)	0.513	0.532	0.508	0.519	0.506	0.520
	Post	97.9(kg)	0.497	0.490	0.505	0.497	0.503	0.499
09	Pre	90.2(kg)	0.481	0.483	0.479	0.468	0.481	0.473
	Post	90.7(kg)	0.482	0.487	0.476	0.485	0.470	0.490
10	Pre	102.5(kg)	0.477	0.469	0.473	0.475	0.471	0.469
	Post	103.4(kg)	0.497	0.484	0.481	0.500	0.492	0.485
11	Pre	112.9(kg)	0.513	0.507	0.512	0.526	0.517	0.508
	Post	106.5(kg)	0.494	0.497	0.490	0.499	0.500	0.488
12	Pre	87.0(kg)	0.461	0.453	0.445	0.431	0.441	0.435
	Post	86.6(kg)	0.463	0.478	0.481	0.462	0.468	0.479
13	Pre	79.3(kg)	0.421	0.428	0.433	0.419	0.417	0.422
	Post	80.7(kg)	0.450	0.450	0.447	0.432	0.411	0.415
14	Pre	77.5(kg)	0.497	0.489	0.503	0.502	0.494	0.497
	Post	78.0(kg)	0.479	0.469	0.481	0.472	0.478	0.490

ISOTONIC FREE WEIGHT SUBJECTS

Margaria-Kalamen: Raw Data

Time (sec.)

Subject #		Weight	Trial 1	Trial 2	Trial 3	Trial 4	Trial 5	Trial 6
01	Pre	89.8(kg)	0.465	0.478	0.469	0.483	0.480	0.467
	Post	90.2(kg)	0.447	0.509	0.445	0.438	0.442	0.432
02	Pre	89.8(kg)	0.507	0.500	0.497	0.484	0.490	0.487
	Post	92.9(kg)	0.492	0.501	0.483	0.503	0.497	0.486
03	Pre	89.8(kg)	0.520	0.526	0.501	0.518	0.516	0.509
	Post	88.4(kg)	0.510	0.510	0.513	0.520	0.505	0.509
04	Pre	87.0(kg)	0.478	0.481	0.475	0.463	0.465	0.466
	Post	87.5(kg)	0.490	0.468	0.472	0.475	0.500	0.472
05	Pre	83.4(kg)	0.442	0.438	0.427	0.431	0.440	0.425
	Post	85.7(kg)	0.433	0.421	0.414	0.409	0.413	0.414
06	Pre	87.0(kg)	0.440	0.448	0.440	0.442	0.444	0.440
	Post	87.5(kg)	0.475	0.486	0.500	0.485	0.492	0.482
07	Pre	79.3(kg)	0.478	0.482	0.475	0.469	0.465	0.471
	Post	82.5(kg)	0.473	0.492	0.462	0.473	0.458	0.482
08	Pre	89.3(kg)	0.452	0.454	0.450	0.449	0.449	0.442
	Post	90.7(kg)	0.470	0.453	0.484	0.461	0.498	0.459
09	Pre	82.0(kg)	0.421	0.427	0.526	0.408	0.417	0.432
	Post	83.0(kg)	0.457	0.459	0.449	0.434	0.441	0.449
10	Pre	84.8(kg)	0.468	0.478	0.472	0.471	0.469	0.474
	Post	85.2(kg)	0.507	0.502	0.516	0.499	0.505	0.492
11	Pre	95.7(kg)	0.517	0.512	0.505	0.510	0.504	0.509
	Post	95.2(kg)	0.501	0.493	0.487	0.480	0.497	0.486
12	Pre	114.3(kg)	0.547	0.550	0.534	0.537	0.546	0.535
	Post	112.9(kg)	0.590	0.572	0.575	0.568	0.582	0.576
13	Pre	75.2(kg)	0.470	0.452	0.449	0.445	0.454	0.450
	Post	78.4(kg)	0.446	0.441	0.430	0.453	0.436	0.444

ISOTONIC MACHINE WEIGHT SUBJECTS

Power Scores: Raw Data

Subject #		Body Weight (kg)	Vertical Distance (meters)	Elapsed Time (sec.)	Power Score (kgm/sec)
01	pre	104.7	1.029	0.530	201.528
	post	106.1	"	0.521	209.631
02	pre	79.8	"	0.442	185.852
	post	81.6	"	0.450	185.461
03	pre	75.7	"	0.458	170.188
	post	76.2	"	0.438	179.025
04	pre	101.1	"	0.571	182.283
	post	102.0	"	0.541	194.117
05	pre	95.2	"	0.518	189.220
	post	95.7	"	0.498	197.757
06	pre	106.1	"	0.561	194.684
	post	104.3	"	0.520	206.449
07	pre	80.7	"	0.513	161.950
	post	83.0	"	0.489	174.671
08	pre	98.8	"	0.506	201.087
	post	97.9	"	0.490	205.748
09	pre	90.2	"	0.468	198.465
	post	90.7	"	0.470	189.614
10	pre	102.5	"	0.469	224.912
	post	103.4	"	0.481	221.242
11	pre	112.9	"	0.508	228.778
	post	106.5	"	0.488	224.764
12	pre	87.0	"	0.431	207.923
	post	86.6	"	0.462	192.961
13	pre	79.3	"	0.417	195.875
	post	80.7	"	0.411	202.142
14	pre	77.5	"	0.489	163.217
	post	78.0	"	0.469	171.172

ISOTONIC FREE WEIGHT SUBJECTS

Power Scores: Raw Data

Subject #		Body Weight (kg)	Vertical Distance (meters)	Elapsed Time (sec.)	Power Score (kgm/sec)
01	pre	89.8	1.029	0.465	198.742
	post	90.2	"	0.432	214.004
02	pre	89.8	"	0.484	190.940
	post	92.2	"	0.485	198.100
03	pre	89.8	"	0.501	184.461
	post	88.4	"	0.505	180.227
04	pre	87.0	"	0.463	193.552
	post	87.5	"	0.468	192.482
05	pre	83.4	"	0.425	202.072
	post	85.7	"	0.409	215.683
06	pre	87.0	"	0.440	204.600
	post	87.5	"	0.475	189.645
07	pre	79.3	"	0.465	175.656
	post	82.5	"	0.458	185.474
08	pre	89.3	"	0.442	208.028
	post	90.1	"	0.453	206.068
09	pre	82.0	"	0.400	207.060
	post	83.0	"	0.434	196.806
10	pre	84.8	"	0.468	186.498
	post	85.2	"	0.492	178.349
11	pre	95.7	"	0.504	195.402
	post	95.2	"	0.480	204.202
12	pre	114.3	"	0.534	220.261
	post	112.9	"	0.568	204.611
13	pre	75.2	"	0.445	174.111
	post	78.4	"	0.430	187.783

APPENDIX D

Orthotron Test

ISOTONIC MACHINE WEIGHT SUBJECTS

Orthotron: Raw Data

(Foot Pounds of Pressure)

Number		Left Leg	Right Leg	Total
01	Pre	530	535	1065
	Post	505	510	1015
02	Pre	435	415	850
	Post	445	470	915
03	Pre	480	425	905
	Post	480	440	920
04	Pre	570	575	1145
	Post	595	600	1195
05	Pre	495	425	920
	Post	485	430	915
06	Pre	370	415	785
	Post	515	495	1010
07	Pre	530	495	1025
	Post	540	535	1075
08	Pre	530	505	1035
	Post	550	525	1075
09	Pre	485	430	915
	Post	480	465	945
10	Pre	525	510	1035
	Post	520	525	1045
11	Pre	445	360	805
	Post	460	365	825
12	Pre	515	410	925
	Post	535	460	995
13	Pre	420	385	805
	Post	525	430	955
14	Pre	430	330	760
	Post	430	355	785

ISOTONIC FREE WEIGHT SUBJECTS

Orthotron: Raw Data

(Foot Pounds of Pressure)

Number		Left Leg	Right Leg	Total
01	Pre	380	370	750
	Post	535	480	1015
02	Pre	510	535	1045
	Post	510	475	985
03	Pre	455	445	900
	Post	460	450	910
04	Pre	500	480	980
	Post	485	480	1000
05	Pre	470	410	880
	Post	560	440	1000
06	Pre	480	475	955
	Post	505	420	925
07	Pre	490	490	980
	Post	515	510	1025
08	Pre	400	425	825
	Post	385	345	730
09	Pre	430	425	855
	Post	490	480	970
10	Pre	455	360	815
	Post	425	405	830
11	Pre	505	420	925
	Post	535	480	1015
12	Pre	565	550	1115
	Post	525	450	975
13	Pre	395	350	745
	Post	425	385	810

APPENDIX E

40 Yard Dash

ISOTONIC MACHINE WEIGHT SUBJECTS

40 Yard Dash: Raw Data

Time (sec.)

Subject #		Trial 1	Trial 2	Trial 3	Avg.
01	Pre	5.52/5.48/5.57	5.52/5.50/5.53	5.57/5.52/5.38	5.51
	Post	5.57/5.53/5.57	5.52/5.50/5.48	5.57/5.52/5.52	5.52
02	Pre	4.88/5.03/4.91	4.94/4.99/4.92	4.97/4.99/4.92	4.95
	Post	4.81/4.71/4.77	4.78/4.74/4.79	4.71/4.68/4.66	4.73
03	Pre	4.80/4.82/4.90	4.77/4.74/4.92	4.83/4.61/4.84	4.80
	Post	4.82/4.79/4.74	4.82/4.84/4.80	4.90/4.97/4.86	4.83
04	Pre	5.40/5.44/5.43	5.50/5.53/5.34	5.46/5.44/5.32	5.42
	Post	5.59/5.54/5.50	5.48/5.50/5.48	5.64/5.48/5.59	5.53
05	Pre	5.39/5.41/5.52	5.39/5.32/5.33	5.25/5.43/5.28	5.33
	Post	5.60/5.58/5.50	5.54/5.53/5.45	5.41/5.33/5.35	5.47
06	Pre	5.49/5.41/5.52	5.40/5.43/5.56	5.53/5.59/5.46	5.48
	Post	5.53/5.56/5.43	5.52/5.49/5.41	5.59/5.46/5.40	5.48
07	Pre	4.90/4.90/4.83	4.81/4.97/4.83	5.00/5.00/4.92	4.90
	Post	4.90/4.84/4.89	4.83/4.89/4.87	4.54/5.11/4.95	4.86
08	Pre	5.40/4.96/5.19	5.36/5.22/5.42	5.22/5.21/5.27	5.25
	Post	5.22/5.36/5.22	5.19/5.21/4.96	5.42/5.40/5.24	5.24
09	Pre	5.15/5.00/5.00	4.94/4.67/4.92	5.02/5.06/5.09	4.97
	Post	5.09/5.06/5.01	5.00/4.93/5.15	4.67/5.00/4.95	4.98
10	Pre	5.16/5.27/5.14	5.15/5.25/5.13	5.24/5.29/5.27	5.21
	Post	5.21/5.18/5.17	5.27/5.25/5.20	5.29/5.21/5.25	5.22
11	Pre	5.14/5.25/5.13	5.15/5.23/5.13	5.25/5.25/5.17	5.18
	Post	5.38/5.34/5.43	5.54/5.53/5.44	5.46/5.50/5.40	5.43
12	Pre	4.95/4.93/5.10	5.00/5.03/4.92	5.00/5.07/5.15	5.01
	Post	4.94/4.84/4.83	5.00/4.98/4.90	5.00/4.81/4.90	4.91
13	Pre	4.95/4.67/5.01	5.00/5.15/5.00	5.09/5.06/4.93	4.98
	Post	4.92/4.91/4.82	4.92/4.85/4.81	4.92/4.89/4.89	4.88
14	Pre	4.96/4.99/5.09	4.99/4.98/5.17	4.99/4.97/5.08	5.02
	Post	4.88/4.92/4.91	4.98/4.99/5.03	4.97/4.94/4.88	4.94

ISOTONIC FREE WEIGHT SUBJECTS

40 Yard Dash: Raw Data

Time (sec.)

Subject #		Trial 1	Trial 2	Trial 3	Avg.
01	Pre	4.96/4.99/5.09	5.00/5.00/5.17	4.98/4.95/5.08	5.02
	Post	4.74/4.92/4.90	4.61/4.74/4.82	4.83/4.77/4.80	4.79
02	Pre	5.09/4.92/5.00	5.06/5.01/5.00	4.67/4.95/5.15	4.97
	Post	5.15/5.17/5.09	4.95/5.00/4.99	4.98/5.00/4.96	5.03
03	Pre	5.00/5.06/5.12	5.01/5.16/5.04	5.12/5.14/5.10	5.08
	Post	5.17/5.13/5.13	5.29/5.25/5.27	5.25/5.15/5.16	5.20
04	Pre	5.08/5.17/5.09	4.97/4.98/4.99	4.99/4.99/4.96	5.02
	Post	5.03/5.16/5.04	5.21/5.18/5.02	5.17/5.22/5.10	5.12
05	Pre	4.67/4.78/4.67	4.66/4.66/4.61	4.71/4.77/4.72	4.69
	Post	4.45/4.60/4.65	4.77/4.66/4.78	4.71/4.65/4.69	4.66
06	Pre	5.17/5.13/5.13	5.23/5.22/5.24	5.24/5.14/5.11	5.17
	Post	5.17/5.13/5.04	5.12/5.24/5.01	5.18/5.24/5.08	5.13
07	Pre	4.92/4.85/4.81	5.00/4.97/4.90	4.95/4.81/4.95	4.90
	Post	4.84/4.84/4.76	4.88/4.89/4.79	4.85/4.86/4.82	4.39
08	Pre	4.93/4.92/4.91	4.99/4.99/5.05	4.97/4.93/5.00	4.96
	Post	4.84/4.71/4.80	4.76/4.69/4.65	4.81/4.80/4.78	4.76
09	Pre	5.00/5.04/5.10	5.01/5.13/5.03	4.94/5.10/5.10	5.05
	Post	5.14/5.03/5.12	5.12/5.14/5.06	4.94/5.01/5.00	5.06
10	Pre	4.95/4.88/4.83	4.81/4.97/4.85	4.95/5.00/4.92	4.90
	Post	4.93/4.93/5.05	5.11/5.13/4.95	5.01/4.98/4.94	5.00
11	Pre	5.59/5.48/5.50	5.48/5.50/5.54	5.64/5.48/5.59	5.53
	Post	5.65/5.64/5.50	5.56/5.54/5.48	5.55/5.54/5.40	5.55
12	Pre	5.40/5.49/5.51	5.56/5.54/5.64	5.55/5.57/5.79	5.56
	Post	5.65/5.75/5.66	5/73/5.71/5.64	5.37/5.65/5.39	5.61
13	Pre	4.89/4.80/4.81	4.87/4.85/4.89	4.91/4.92/4.92	4.87
	Post	4.81/4.81/4.81	4.83/4.71/4.62	4.90/4.90/4.98	4.81

APPENDIX F

Analysis of Variance for Margaria-Kalamen, Orthotron and 40-Yard Dash for both the Machine and Free Weight Groups

Table 7

Analysis of Variance Pre-test on Margaria-Kalamen
for Machine and Free Weight Groups

Source	df	Sums of Square	Mean Square	F
Between	1	34.0625	34.0625	0.1155
Within	25	7371.1250	294.8450	
Total	26	7405.1875		

Table 8

Analysis of Variance Post-test on Margaria-Kalamen
for Machine and Free Weight Groups

Source	df	Sums of Square	Mean Square	F
Between	1	6.9375	6.9375	0.0337
Within	25	5149.7500	205.9900	
Total	26	5156.6875		

Table 9

Analysis of Variance Pre-test on Orthotron
for Machine and Free Weight Groups

Source	df	Sums of Square	Mean Square	F
Between	1	3088.00	3088.00	0.2346
Within	25	329056.00	13162.23	
Total	26	332144.00		

Table 10

Analysis of Variance Post Test on Orthotron
for Machine and Free Weight Groups

Source	df	Sums of Square	Mean Square	F
Between	1	11568.00	11568.00	0.1691
Within	25	247376.00	9895.00	
Total	26	258944.00		

Table 11

Analysis of Variance Pre-test on 40-yard Dash
for Machine and Free Weight Groups

Source	df	Sums of Square	Mean Square	F
Between	1	0.0520	0.0520	0.9221
Within	25	1.4099	0.0564	
Total	26	1.4619		

Table 12

Analysis of Variance Post-test on 40-yard Dash
for Machine and Free Weight Groups

Source	df	Sums of Square	Mean Square	F
Between	1	0.0977	0.0977	0.9911
Within	25	2.4634	0.0985	
Total	26	2.5611		