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A Comparison of Two Explosive Power Tests for a Variety of College Athletes

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A COMPARISON OF TWO EXPLOSIVE POWER TESTS FOR A VARIETY OF COLLEGE ATHLETES

(TITLE)

BY

JAMES LEO FEHRENBACHER

THESIS

SUBMITTED IN PARTIAL FULFILLMENT OF THE REQUIREMENTS
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Chapter 1

INTRODUCTION

There are many requisites which are necessary for an outstanding motor performance, but one of the most basic is muscular power. Since all motor activities involve some form of movement, and muscular power is a component of movement, one can ascertain that power would be a definite asset for an optimum performance.

Most physical educators and coaches agree that along with other assets, an athlete must possess muscular power. Doherty (11:6) contends that power is a very important factor in success of the track and field athlete. In addition, Van Dalen (28:82-96) investigated the role of explosive muscular power in certain track and field events. Dyson (12:43-44) also believes power is an important component of athletic performance. He feels that in athletics not only the work performed is important, but also the time taken to do it, and power is the rate at which work is being done. Broer (6:33) agrees that muscular power influences the degree of effective movement in athletics.

The question then arises as to how to determine the amount of explosive power an individual possesses. There are various tests which measure explosive power and the purpose of this paper is to investigate two of these explosive power tests.

PURPOSE OF THE STUDY

The primary purpose of this investigation was to determine the relationship between two explosive power tests, the Sargent Jump Test and the Margaria-Kalamen Power Test, using a variety of college athletes as subjects. In addition, inter-athletic group comparisons were studied.

NULL HYPOTHESIS

There is no relationship between the Sargent Jump Test and the Margaria-Kalamen Power Test.

There is no difference in explosive power, as measured by the above two tests, between the various athletic groups involved in this study.

LIMITATIONS OF THE STUDY

The subjects were selected from the varsity teams active during the winter and spring quarters of 1972-1973 at Eastern Illinois University.

Because of the limited availability of the subjects, only one exposure to each explosive power test was given each subject.

Due to conflicts with national meet competition, the subjects involved in swimming and gymnastics were tested after the completion of their season.

DEFINITION OF TERMS

For the purpose of this investigation, the following terms are defined:

Explosive Muscular Power

The capacity of an individual to bring into play maximum muscular contraction at the optimum rate of speed.

Sargent Jump Test

Measure of explosive power determined by subtracting ones standing reach height with the maximum height he can jump and touch a marked board with his pre-chalked dusted finger tips.

Margaria-Kalamen Power Test

Measure of explosive power determined by the time it takes a person to move his body weight, after a six meter run-up, from the third to the ninth step on a pre-marked staircase, taking three stairs with each stride.

Chapter 2

REVIEW OF RELATED LITERATURE

There have been numerous studies conducted pertaining to explosive muscular power. The review of the related literature in this chapter will be primarily of a historical nature in order to reveal past and recent studies which relate to various aspects of muscular power. This chapter will be subdivided into three areas: 1) the development of muscular power tests; 2) the effects of various training methods on muscular power; 3) the relationship of various physical characteristics to muscular power.

THE DEVELOPMENT OF MUSCULAR POWER TESTS

One of the pioneers in the development of muscular power tests was Dr. D.A. Sargent. In 1921, Sargent (24:188) presented a new test which he called "the physical test of man". This test consisted of jumping into the air as high as possible and taking as the record of the jump the difference between the height reached by the crown of the head and the standing height.

The Sargent Jump test became so popular that in 1924, L.W. Sargent (25:47) made an in-depth study to see if he could find any significant relationship between the Sargent Jump and body build, relative leg length, height,

weight or other anthropometric measurements. He found no significant correlations nor did he find any significant relationship between the height of the jump and the amount of squat or dip which proceeded the actual jump.

In another study conducted by Bovard and Cozens (4:51) in 1928, the relationship between the Sargent Jump and various athletic tests was investigated. They found that with a group of college students exhibiting a high degree of athletic ability, a multiple correlation of .55 was obtained between the Sargent Jump and four athletic events which were: 1) the running high jump; 2) the standing broad jump; 3) the rope climb for speed; 4) the 880 yard run.

In 1933, MacCurdy (18:59) developed a different type of power test based on a "Force Index". This index correlated (.52) with the Cozens (modified) test. He then multiplied the index figure times the vertical jump to arrive at a "Power Capacity Index".

By the year 1940, muscular power testing was still heavily centered around the vertical jump. Larson (17:82-96) found that a combination of chinning, dipping, and vertical jump was a good test of muscular power. Displaying a correlation of .685 with an "All Round Athletic Criterion" he devised, as compared to .521 for the MacCurdy Power Capacity Test.

Also in the year 1940, Van Dalen (28:82-96) used 106 high school boys ranging in age from 15 to 17 years in studying various methods of administering the Sargent Jump

Test. He found that when the Sargent Jump is standardized, practiced, and correctly administered, it is undoubtedly a valuable test for predicting the ability to develop power.

McOloy and Young (21:74) agreed with Van Dalen. They found that by offering adequate practice in the technique of jumping, and selecting the best jump from two series of jumps each, that the reliability coefficient of the Sargent Jump was .854.

THE EFFECTS OF VARIOUS TRAINING METHODS ON MUSCULAR POWER

By 1950, researchers were beginning to turn their attention to what effects various training methods would have on muscular power.

In mid-1950, Chui (9:188-194) found that a systematic weight training program increased the amount of potential power. He contended that power (force times velocity), in the human body is apparently limited by muscular viscosity. The greater the speed of contraction, the more force is required to overcome the viscosity of the muscle. With an increase in the strength, however, more force can be used to overcome the viscosity of the muscle, and to force the maximum velocity to higher levels.

In a study by Capen (8:83) completed about the same time as Chui's study, he reported that no muscular tightness or decreased speed of muscular contraction resulted from an eleven week weight training program of 42 male college

sophomores. This was a very significant study because if weight training decreased the speed of muscular contraction it could also decrease muscular power.

By the late 1950's and early 1960's, weight training was still of primary interest to researchers of muscular power.

In 1957, Brown and Riley (7:44) studied the effects of a five week weight training program on leg strength, ankle planter flexion, and vertical jump. They used 40 male college freshman basketball candidates as subjects. They found a significant increase in leg strength, ankle planter flexion, and vertical jump after the weight training program was completed.

In a study by Nelson (22:581-587) in 1962, 18 male college physical education majors were used to study the effect of swimming and basketball on the performance of three explosive power tests: 1) start and run; 2) standing broad jump; 3) the shot put. He found that different types of activity affect different explosive power tests in varying degrees.

Berger (2:419-423) conducted a study on the effect of weight training on muscular power in 1963. He tested 89 male college students to determine the effect of strength improvement on vertical jumping ability using dynamic and static weight training methods. He found dynamic overload training was more effective for increasing vertical jumping ability than static overload training. He also found a

significant increase in static strength does not guarantee an improvement in vertical jumping ability.

Ball, et al., (1:231-235) in a study conducted in 1964, agreed with Berger's results. They used 63 college men to test the effects of isometric training on the vertical jump. They also concluded that gains in ability to exert isometric force as a result of isometric training was not accompanied by an increase in vertical jump.

McClements (20:71-78) used 86 college men enrolled in physical conditioning classes to test the relationship of power to thigh and leg strength. He reported that: 1) the development of the strength of the leg and thigh extensors; 2) the development of the strength of the leg and thigh flexors and extensors; 3) the development of the strength of the leg and thigh flexors; and 4) the development of the fitness of the total body were equally effective in causing increases in the power of the leg and thigh muscules used in the vertical jump.

THE RELATIONSHIP OF VARIOUS PHYSICAL CHARACTERISTICS TO MUSCULAR POWER

The relationship of various physical characteristics to muscular power has been an area of vital interest to coaches and physical educators down through the years.

In 1937, Rarick (23:89) made an analysis of the speed element involved in an athletic performance. He reported an average correlation of .120 between leg lift strength and a vertical jump without arm action, for 51 male

college students.

Also in the year 1937, Harris (14:114) tested 163 junior high school girls and found a coefficient of .215 between an undetailed measure of leg strength and the ordinary Sargent Jump.

A similar study conducted by Smith (26:405-408) in 1961, reported that no relationship existed between vertical jumping without the arm swing and explosive muscular leg strength or the ratio of leg strength to body mass on 70 college men.

Gray, et al., (13:395-399) tested 62 college male students in 1962, for leg speed as measured by the bicycle ergometer and leg power as measured by the vertical jump. They found a correlation of .47, which was significant at the .001 level.

In 1966, Berger and Henderson (3:9-13) investigated the relationship of power to static and dynamic strength on 66 male college students. They concluded that dynamic leg strength and static leg strength are both related to leg power, but neither dynamic or static leg strength is more related to leg power.

Costill, et al., (10:785-787) conducted a study in 1968, in which they tested 76 college males on a variety of explosive leg strength and power tests. They report it is possible that anaerobic power is significantly related to dynamic leg strength as measured by the squat weight lift. Vertical velocity is related to speed (40 yard dash), but

only moderately influenced by explosive leg strength (vertical jump and standing broad jump).

In 1971, Jackson (16:50-51) compared athletes and non-athletes in reaction time, running speed, and explosive power. He used 142 male undergraduate students. Using a modified version of the Sargent Jump, he found a significant relationship between the vertical jump (explosive power) and reaction time for the athletic group. He also found a significant relationship between explosive power, running speed, and body weight for both the athletic and non-athletic groups.

A somewhat different investigation of leg power was conducted by Huffman and Berger (15:468-471) in 1972. They used 50 male college students to determine if relative or absolute leg power was a better predictor of physical performance. They found that both absolute and relative leg power predict physical performance with similar accuracy.

SUMMARY

The subject of explosive muscular power has been researched from a diversity of viewpoints through the years. This research builds upon itself and it seems to be concentrated in three major areas: 1) the development of better explosive muscular power tests; 2) determining the effect of various training methods on muscular power; and 3) the effect of various physical characteristics on muscular power.

Chapter 3

METHODOLOGY

This study was designed to determine the relationship between two explosive power tests, the Sargent Jump Test and the Margaria-Kalamen Power Test. It was also designed to compare various athletic groups on each power test. This chapter will contain a description of the subjects, experimental design, and testing procedures.

SUBJECTS

The subjects for this study were 69 male undergraduate students at Eastern Illinois University. Each subject was a member of a varsity athletic team during the winter and spring quarters of 1972-73 school year. The following athletic groups were selected with the number of subjects in each group in parenthesis: basketball (10), wrestling (10), gymnastics (7), swimming (7), baseball (10), tennis (8), golf (7), and distance runners from the track team (10). The subjects weight ranged from 126 pounds to 264 pounds with the mean weight being 165.28 pounds.

The subject selection was made with the help of the coaches from each varsity team and were chosen as representative of the best all-around athletes from each team. Many of the subjects were national and school champions and record holders.

EXPERIMENTAL DESIGN

There were two basic tests administered in this study. They were the Sargent Jump Test and the Margaria-Kalamen Power Test. Each group of subjects performed both tests on the same day. It was felt that because of the nature of the two tests a very minimal amount of work was required of the subjects, therefore, they would be able to perform both tests on the same day with no performance reduction due to fatigue.

The subjects reported to the testing area with their athletic group. They were then randomly placed in two smaller groups of equal size. One group would perform the Sargent test first, while the other group performed the Margaria-Kalamen test first. After they completed the first test, they would then move to the other test. This procedure was adopted in order to partial out any psychological or physiological advantages or disadvantages that might have been present had each subject performed the same sequence of tests.

TESTING PROCEDURES

Preliminaries

The testing area was set up in the northeast corner of the Lantz Gym Fieldhouse at Eastern Illinois University. When the subjects entered the testing area, each subject's name was recorded on two data sheets, one for each power test. Each subject was then weighed in his

gym shorts, supporter, socks, gym shoes, and t-shirt on a calibrated Healthometer Scale. His weight was read to the nearest quarter-pound and recorded on the data sheets. He was then randomly placed into one of two smaller groups which determined what sequence he would perform the two power tests.

Sargent Jump Test

Equipment--A blackened touch board, which was premarked in inches, was used to record the height jumped by each subject. The touch board was secured to a hand railing on the balcony of the Lantz Gym Fieldhouse in such a manner as to be easily reached by the subjects for their standing reach measurement, yet high enough to provide an accurate measurement of the jump without a subject jumping beyond the upper limits of the board.

Originally, the test was to measure the time in the air of each jump for each subject. Due to malfunction of the Dekan Athletic Performance Timer while testing the second group of subjects, the timing aspect of the study had to be eliminated. Since the first two groups of subjects initiated their jumps from a switch mat, the mat was retained as part of the test in order to be consistent, even though no times were being recorded.

Orientation--The subjects were given a complete orientation of the proper execution of the Sargent Jump Test before any jumps were taken.

Procedures for the Sargent Jump Test were similar to those suggested by McCloy and Young (21:74). The subject stood on the switch mat with either the left or right side of the body towards the touch board. With the arm closest to the touch board, he would reach as high as possible and make a mark on the board with chalk-dusted fingertips, making sure his heels were flat on the mat. The subject would then execute the jump by swinging his arms downward and backward, squat down and slightly forward and form approximately a ninty-degree angle at the back of the knee, pause momentarily in this position to eliminate the possibility of a double jump. He would then jump upward to the vertical and just before the highest point of the jump is reached, swing the non-chalked arm forward and downward to the side to coincide exactly with the end of the upward movement of the body, and then make a mark on the touch board. The subjects were then encouraged to give an optimum performance.

Procedures--Each subject was given three jumps and if he felt he could perform a better jump than his previous three, he was given as many jumps as he felt he would need to obtain his optimum performance.

Measurement of the standing reach and the height jumped was read to the nearest half inch. The actual height of the jump was determined by subtracting the standing reach height from the height jumped.

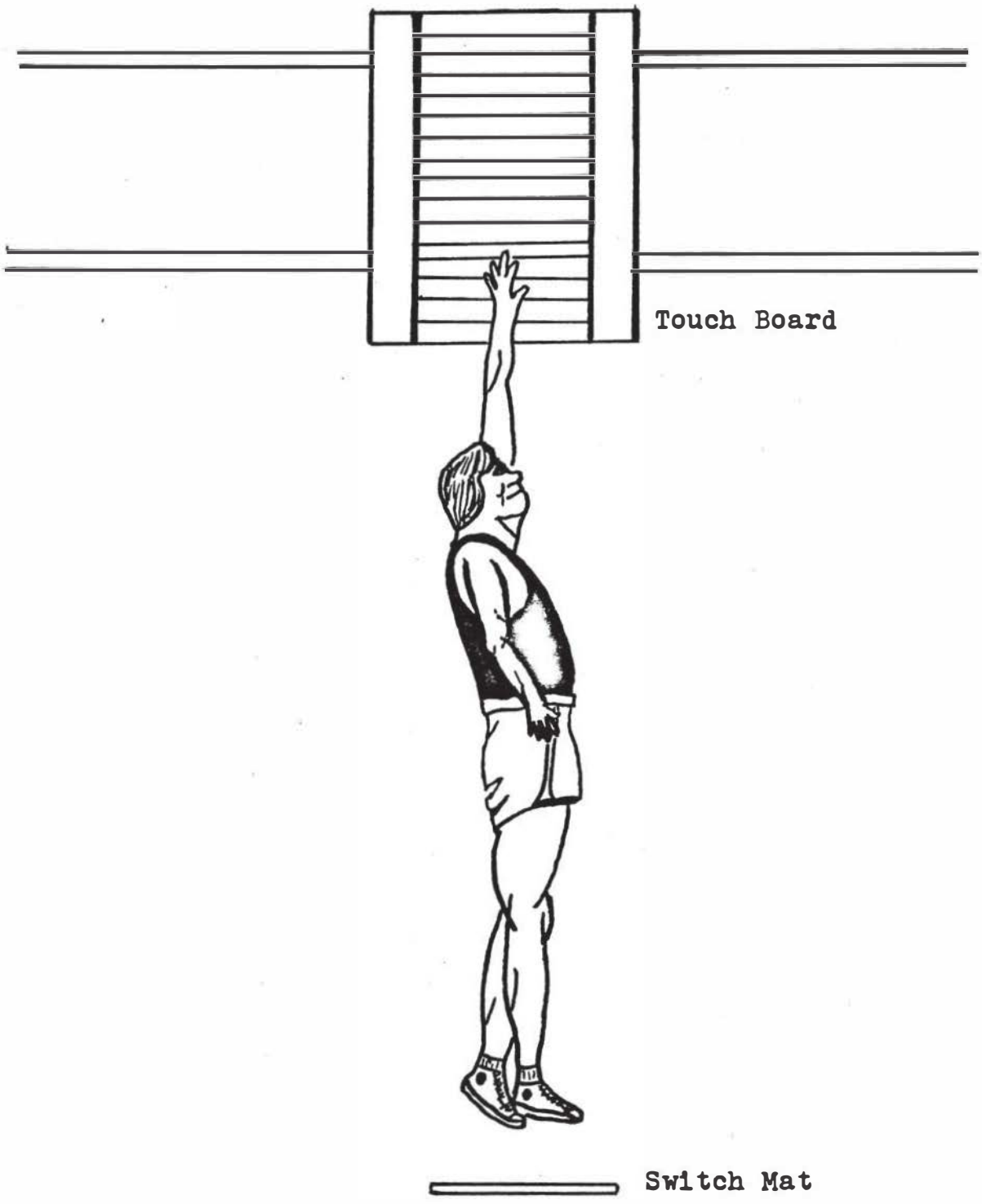

Figure 1

Sargent Jump Test

Margaria-Kalamen Power Test

Equipment--A staircase which contained at least nine steps was needed for this test. The staircase at the northeast corner of the Lantz Gym Fieldhouse was selected as the sight of the test, for it consisted of twelve 7½ inch steps. Since the test required running up three stairs at a time at full speed, the third, sixth and ninth steps were painted yellow in order to give the subject a visual target.

The object of the test was to time the subject's run from the third to the ninth step. The timing device used in this particular test was a Motor Performance Timer. This timer consisted of a foot switch strip placed on the third step to start the clock and a second foot switch strip was placed on the ninth step to stop the clock. The switch strips were connected to a switch box which in turn was connected to a Standard Electric Timer that recorded the performance time of the subject to the nearest hundredth of a second.

Orientation--All subjects were given an orientation before any trials were run.

Procedures for the Margaria-Kalamen Power Test were similar to those suggested by Mathews and Fox (19:200). The subject stood toeing a chalked starting line, which was pre-measured six meters from the bottom of the first step. Upon his own discretion, he would run to the staircase and up the stairs taking three steps at a time, first hitting the third step, then the sixth step, and finally the ninth

step. The subjects were told to run as fast as they could possibly run, but to make sure they kept their eyes on the steps to prevent an injury. Timing switches were placed on the third and ninth steps to record their performance time.

Procedures--Each subject was given six trials. If the timer malfunctioned or the subject missed the start or stop switches, another trial was given. If the subject felt he could do better after six trials, additional trials were allowed in order to obtain his optimum performance.

The subjects performed the test in groups of two. While one subject was being tested, the other subject was returning to the starting line. Approximately 15-20 seconds elapsed between each trial.

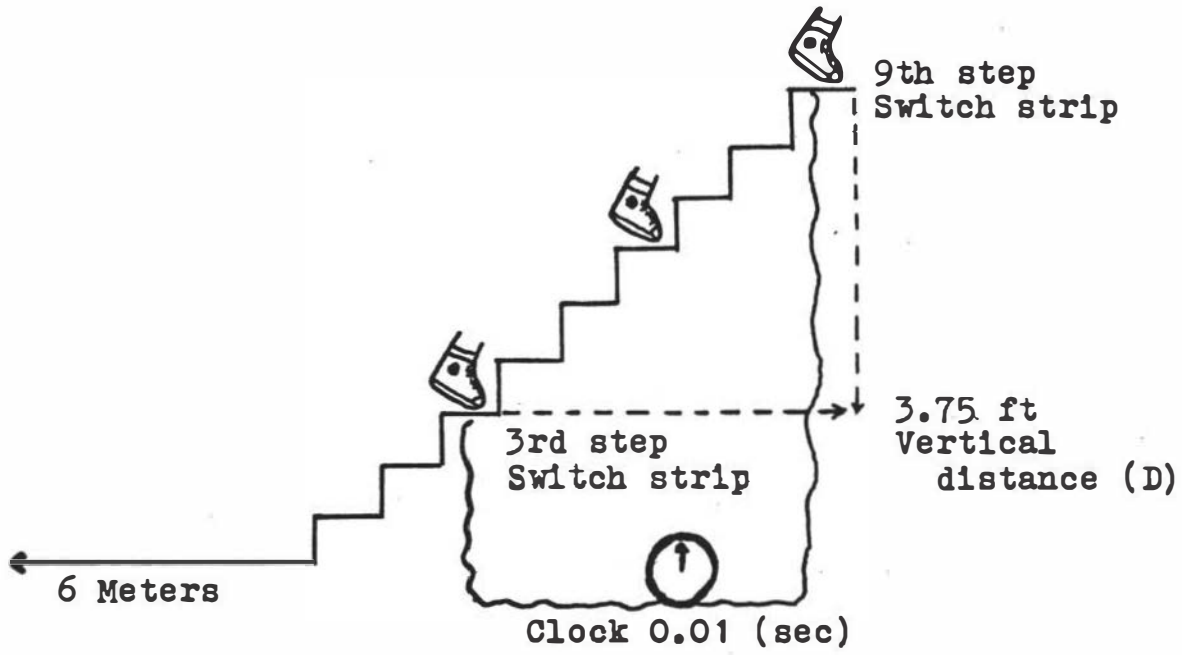

Figure 2

Margaria-Kalamen Power Test

Chapter 4

ANALYSIS OF DATA

The investigation was designed to study the relationship between two explosive power tests, the Sargent Jump Test and the Margaria-Kalamen Power Test. In addition, the scores made by various athletic groups on the Sargent Jump Test were compared to the Margaria-Kalamen Power Test scores. Sixty-nine members of varsity athletic teams, active during the winter and spring quarter of the 1972-73 school year at Eastern Illinois University, acted as subjects for the study.

DATA CONVERSION

The height jumped in the Sargent Jump Test, the performance time from the third to the ninth step in the Margaria-Kalamen Power Test, and the subjects body weight were then used in two separate equations to derive a "Power Index" figure for each subject for each power test. The equation used for the Sargent Jump Test was:

$$\text{Power Index} = \frac{\text{Body Weight} \times \text{Height Jumped}}{1{,}000}$$

Body weight was described in pounds, while height jumped was recorded to the nearest half inch.

The "Power Index" equation for the Margaria-Kalamen Power Test was (Mathews and Fox, 19:200):

$$\text{Power Index} = \frac{\text{Body Weight} \times \text{Distance}}{\text{time}}$$

Body weight was described in pounds. The Distance was the measured distance from the third to the ninth step, a constant of 3.75 feet. The time it took to travel this distance was recorded to the nearest hundredth of a second.

STATISTICAL TREATMENT

The degree of relationship between the Sargent Jump Test and the Margaria-Kalamen Power Test was computed by employing the Pearson-Product Moment correlation technique.

A *t* test was employed to determine the significance of the differences between the means of each athletic group for both power tests.

To establish statistical significance, the .05 level of confidence was selected for the study. Tables from Tate (27:560) were used to determine the integer denoting statistical significant *t* and *r* values.

FINDINGS

The findings have been subdivided into two parts, the relationship of the Sargent Jump Test to the Margaria-Kalamen Power Test, and the inter-athletic group comparisons.

Relationship of the Sargent Jump Test to the Margaria-Kalamen Power Test

The relationship between the Sargent Jump Test and the Margaria-Kalamen Power Test yielded an $r = +.787$. This reveals a very high degree of relationship, significant at the .001 level of confidence, as can be seen in Figure 3. Therefore, one can ascertain that the Sargent Jump Test and the Margaria-Kalamen Power Test are essentially testing the same power output.

Inter-Athletic Group Comparisons

The Sargent Jump Test--Figure 4 shows the mean "Power Index" scores on the Sargent Jump Test for the eight athletic groups. The basketball players, who must be able to jump well and accelerate quickly, had the highest mean power index score. The distance runner's group had the lowest mean power index score as was expected because the mechanics of distance running does not require an extreme amount of explosive muscular power.

Table 1 contains the mean power index scores and *t* scores that describe inter-athletic group comparisons.

For the Sargent Jump Test, the basketball group had the highest mean power index score, with the baseball and the tennis groups next in order. The basketball group and the baseball group demonstrated significantly more power than the swimmers, distance runners, wrestlers, gymnasts, and golfers.

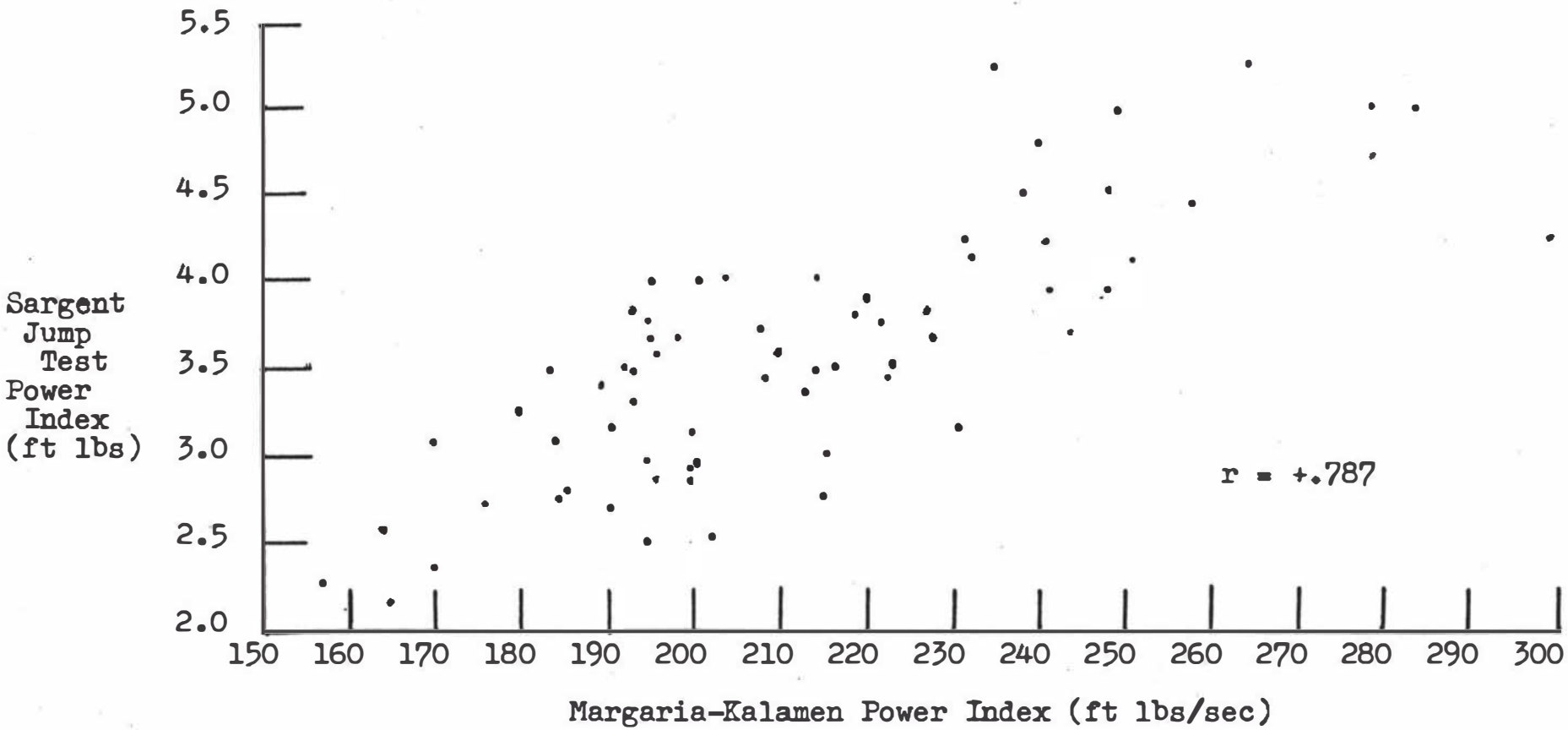

Figure 3

Relationship Between Sargent Jump Test

and Margaria-Kalamen Power Test

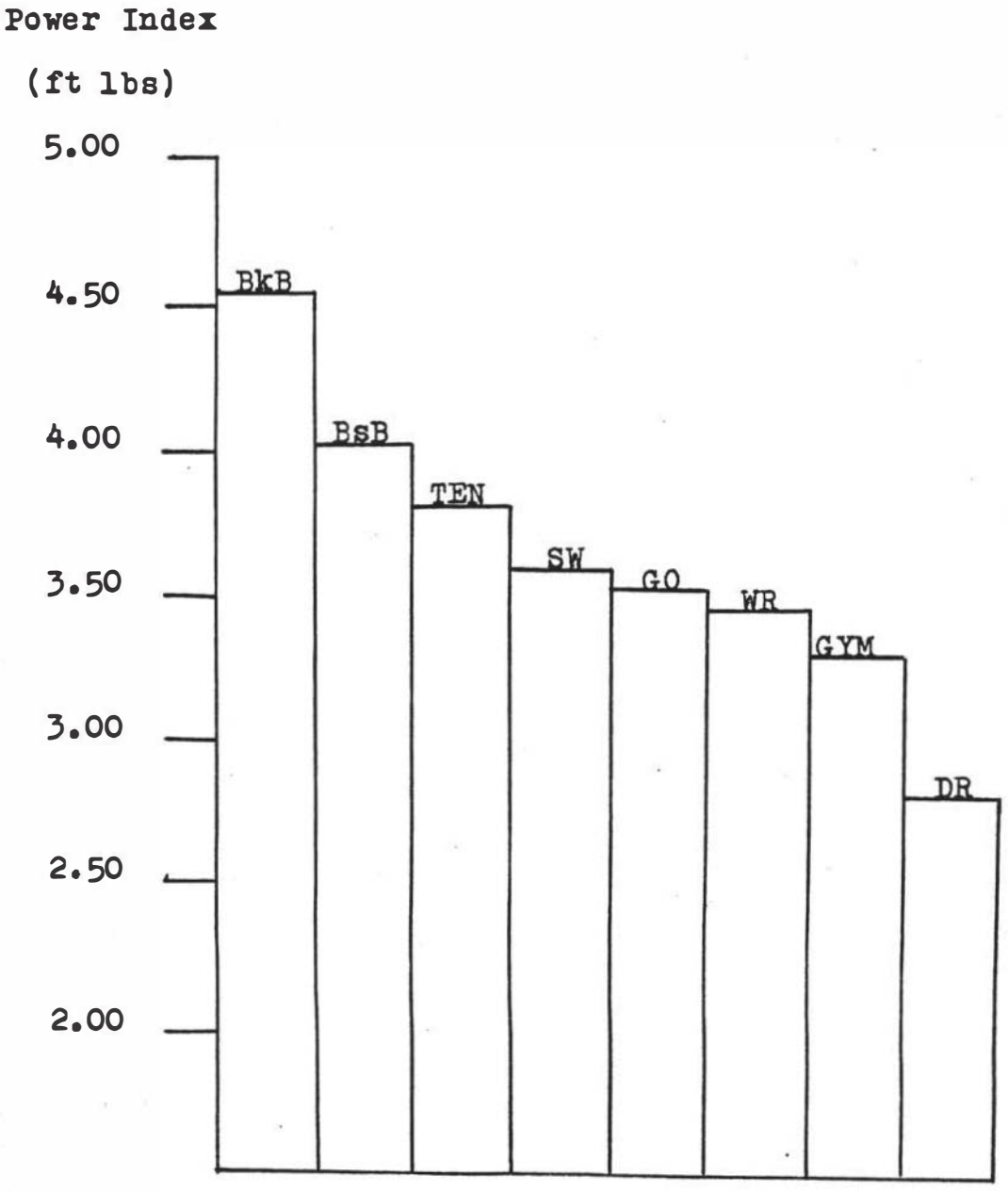

Figure 4

Summary of Mean Scores

Sargent Jump Test

Table 1

Mean Power Index Scores and Inter-Athletic Group

t Scores for the Sargent Jump Test

Groups	Mean Power Index Scores (ft lbs)	BkB	BsB	TEN	SW	GO	WR	GYM	DR
BkB	4.53		2.05	2.00	3.61[b]	3.71[b]	3.91[b]	4.53[a]	7.49[a]
BsB	4.04			.579	2.32[c]	2.45[c]	2.46[c]	3.49[b]	7.44[a]
TEN	3.87				.846	1.09	1.26	1.70	4.13[a]
SW	3.61					.523	.609	1.67	5.78[a]
GO	3.51						.177	.876	4.10[a]
WR	3.47							.568	3.29[b]
GYM	3.32								3.23[b]
DR	2.76								

[a]Significant at the .001 level
[b]Significant at the .01 level
[c]Significant at the .05 level

The distance runners recorded the lowest mean score for the Sargent Jump Test and the other athletic groups demonstrated a significantly greater degree of explosive power than the distance runners.

The tennis, swimming, golf, wrestling, and gymnastic groups had similar mean power index scores and no significant differences were found between any of these groups.

The Margaria-Kalamen Power Test--Figure 5 reveals the mean "Power Index" scores for each of the athletic groups on the Margaria-Kalamen Power Test. Though the absolute value of the power index scores is markedly different than those reported in Figure 4 for the Sargent Jump Test, it can be seen that with only two exceptions, the eight athletic groups are found in the same rank order as they were following the Sargent Jump Test. The only differences in the two tests were the positions of the wrestlers (6th to 4th) and the swimmers (4th to 6th).

Table 2 contains the mean power index scores and the *t* scores for each inter-athletic group comparison.

This table reveals that the basketball group had the highest mean score for the Margaria-Kalamen Power Test as it did for the Sargent Jump Test. The basketball group was found to demonstrate a significantly higher degree of power than the distance runners, swimmer, gymnast, and golf groups.

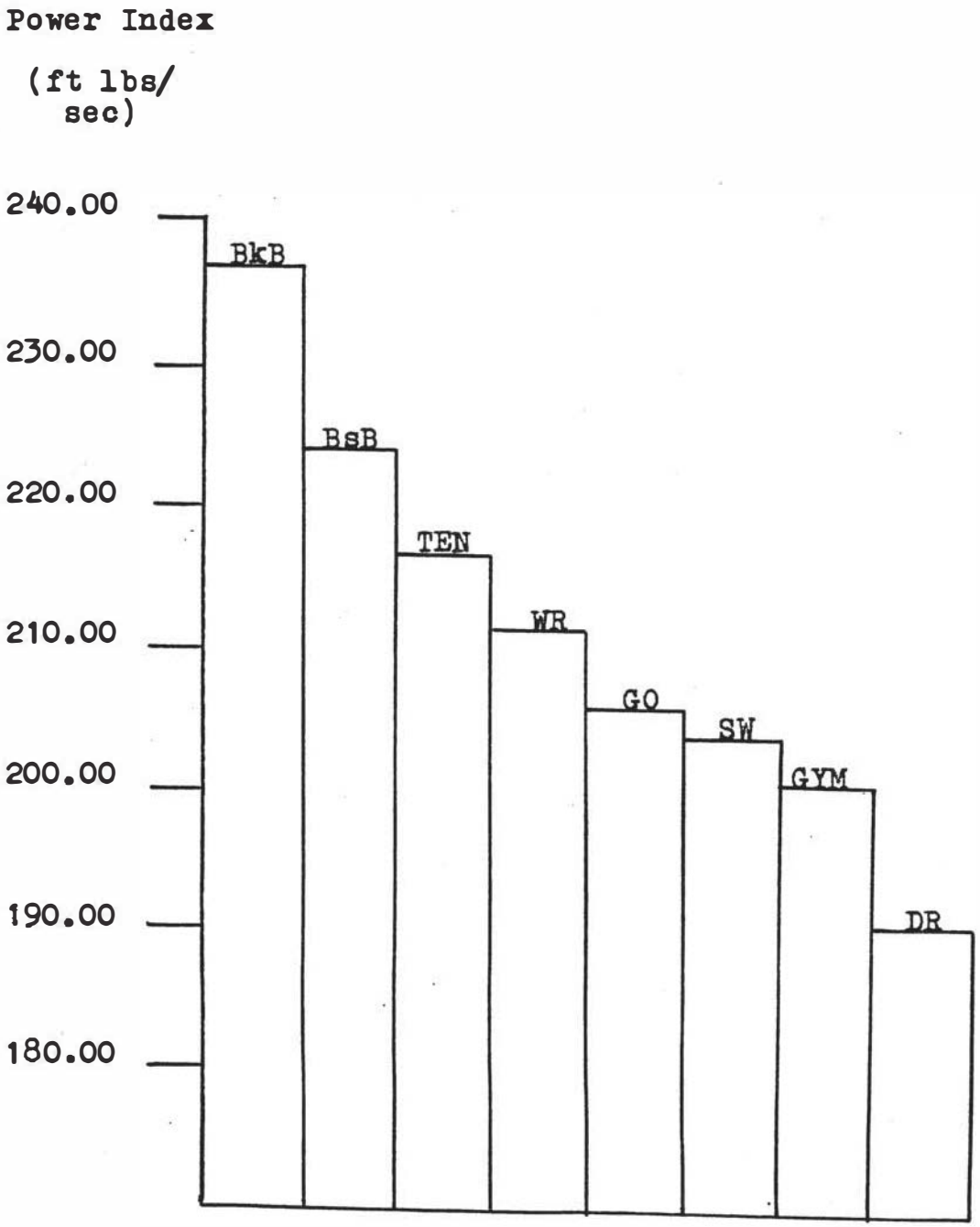

Figure 5

Summary of Mean Scores Margaria-Kalamen

Power Test

Table 2

Mean Power Index Scores and Inter-Athletic *t* Scores

for the Margaria-Kalamen Power Test

Groups	Mean Power Index Scores (ft lbs/sec)	BkB	BsB	TEN	WR	GO	SW	GYM	DR
BkB	237.60		.925	1.46	1.52	2.16[c]	2.65[c]	2.62[c]	4.35[a]
BsB	224.65			.499	.749	1.27	1.66	1.72	3.27[b]
TEN	218.15				.350	.930	1.48	1.48	3.27[b]
WR	212.46					.306	.503	.652	1.67
GO	207.16						.287	.488	1.94
SW	204.39							.341	2.30[c]
GYM	201.32								1.38
DR	189.22								

[a]Significant at the .001 level
[b]Significant at the .01 level
[c]Significant at the .05 level

The distance runners group also recorded the lowest mean score for the Margaria-Kalamen Power Test as they did for the Sargent Jump Test. The basketball, baseball, swimmer, and tennis groups demonstrated a significantly higher degree of power than the distance runners group.

The baseball, tennis, wrestler, golf, swimmer, and gymnast groups had similar mean power index scores and no significant differences were found among these groups.

Chapter 5

SUMMARY, CONCLUSIONS, AND RECOMMENDATIONS

SUMMARY

The investigation was designed to study the relationship of the Sargent Jump Test and the Margaria-Kalamen Power Test. In addition, scores of various college athletic groups for each power test were studied.

Sixty-nine male undergraduate students at Eastern Illinois University were the subjects in the investigation. Each subject was a member of a varsity athletic team during the winter and spring quarter of the 1972-73 school year. The following athletic groups were selected with the number of subjects in each group shown in parenthesis: basketball (10), wrestling (10), gymnastics (7), swimming (7), baseball (10), tennis (8), golf (7), and track distance runners (10). Many of the subjects were national and school champions and record holders.

Each subject was administered the Sargent Jump Test and the Margaria-Kalamen Power Test. A power index score, based on body weight, was determined for each subject on each power test. The power index scores were punched on IBM cards and fed through a computer for statistical analysis. A correlation matrix was used to determine the relationship

of the Sargent Jump Test and the Margaria-Kalamen Power Test, and *t* scores were used to compare the athletic groups tested.

CONCLUSIONS

Based on the findings presented and within the limitations of this investigation, the following conclusions appear warranted:

1. There is a significant relationship between the Sargent Jump Test and the Margaria-Kalamen Power Test.
2. Basketball players possess significantly greater explosive muscular power than the distance runners, swimmers, gymnasts, wrestlers, and golfers.
3. Baseball players possess significantly greater explosive muscular power than the swimmers, distance runners, wrestlers, gymnasts, and golfers.
4. Distance runners possess significantly less explosive muscular power than basketball players, gymnasts, golfers, tennis players, swimmers, wrestlers, and baseball players.

RECOMMENDATIONS

Based on the findings of the study, the following recommendations appear warranted:

1. A similar study should be done that would use both athletes and non-athletes as subjects.
2. A similar study should be done employing a larger and more representative sample of athletic groups.
3. Further studies should be carried out using explosive muscular power test as predictors of athletic ability.

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VITA

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The writer was born in Olney, Illinois, July 17, 1948. He received his elementary and secondary education through the Olney school system. He attended East Richland High School and participated in cross country and track.

In the fall of 1966, he entered Eastern Illinois University in Charleston, Illinois, where he majored in physical education. He was a member of the Eastern Illinois University cross country team which won the NCAA College Division Cross Country Championship in 1968 and 1969. He was a member of the Physical Education Majors Club, the Varsity Club, and the Fellowship of Christian Athletes. He received his Bachelor of Science degree in November, 1970.

In January, 1971, he entered the U.S. Army. While on active duty, he received the Army Commendation Medal.

He married the former Rebecca Jill Snyder of Flora, Illinois in August, 1971.

He returned to Eastern Illinois University in the fall of 1972, where he accepted a graduate assistantship in physical education. He received an M.S. in Physical Education degree in August, 1973, and took a teaching and coaching position at Oakview Junior High School in New Lenox, Illinois for the following school year.