THE RELATIONSHIP BETWEEN THE IMPROVEMENT OF LEG STRENGTH AND SKATING VELOCITY

Thesis for the Degree of M. A.
MICHIGAN STATE UNIVERSITY

Anthony S. Paige

1968

ABSTRACT

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Statement of the Problem

This study was designed with the intent of determining the relationship between the improvement of leg strength and skating velocity. It was also in the design of this problem to devise a leg strength training program for hockey players that required a minimum of time and equipment.

Procedure

After initial and final tests for leg strength and average velocity were administered, a sample of sixteen available subjects was divided according to an alternating ranking method of eight subjects each. The experimental subjects participated in the leg strength program for a period of six weeks. During this same six week period, both the control and the experimental groups participated in the regular hockey training program. At the end of six weeks both groups were tested for leg strength and average velocity.

Leg strength was measured by a back and leg dynamometer. Average velocity was measured by an electric

timer. Leg strength and average skating velocity were compared and a correlation of -.180 was obtained.

The experimental group showed a statistically significant increase in leg strength at the end of the six-week training program. Velocity did not improve significantly from initial test in either the experimental or control group.

Conclusions

1. The leg strength training program described in this study can produce a significant increase in leg strength at the .05 level in six weeks or less.

2. The increase in leg strength did not produce any significant increase in velocity at the .05 level.

It is possible that a much larger increase in leg strength is necessary to significantly improve velocity. There may be other basic skill factors, not measured in this experiment, that combined to off set the leg strength improvement.

Furthermore, a similar increase in leg strength in a larger sample of the total population might result in a corresponding increase in the average skating velocity.

3. A significant increase in leg strength does not have an inhibitive effect on skating velocity. This is in agreement with other studies that have shown that weight training and strength increases do not have a slowing effect on speed of muscle contraction (30, 31).

4. The correlation computed in this report for leg strength and average skating velocity, -.180, may be misleading and would probably be higher if appropriate variables such as weight were controlled.

Approved Dale Mikesell

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By

Anthony S. Paige

A THESIS

Submitted to
Michigan State University
in partial fulfillment of the requirements
for the degree of

MASTER OF ARTS

Department of Health, Physical Education,
and Recreation

1968

ACKNOWLEDGMENTS

The author wishes to express his sincere appreciation to his advisor, Dr. Gale Mikles, for his interest, supervision and guidance of this study.

Thanks are extended to the 1967-68 Michigan State freshman hockey team and their coach for participating as subjects for this investigation.

DEDICATION

To Laurie, my wife, for her patience and understanding during this past year.

Also, to Coach and Mrs. Amo Bessone, our boundless gratitude could never match their helpfulness and hospitality shown to us during our stay here at Michigan State.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

CHAPTER I

INTRODUCTION TO THE PROBLEM

In competitive skating today it is possible for one-tenth of a second to separate first and third place. In ice hockey, the most important requisite is to be an excellent skater. The possibility that leg strength is highly correlated to the skating sprint leads in turn to the possibility of increasing an individual's total skating speed by increasing leg strength.

Synopsis of the Related Literature

There is a wealth of material in the literature concerning leg strength and its effect on running ability and other athletic events. But, there is a definite gap in the literature concerning leg strength and its effect on the skating sprint or even on competitive skating in general.

Statement of the Problem

This study was designed with the intent of determining the relationship between the improvement of leg strength and the velocity of the skating sprint. It was also in the design of this problem to devise a leg strength training program for skaters that requires a minimum of time and equipment.

Need for the Study

Few coaches involved in ice sports dealing with speed would deny the fact that an increase in speed would lead to better performances. In speed skating the swiftness of the skater is an obvious factor in his level of performance. Also, in ice hockey it is readily accepted that the superior skaters are also the best players. Since this entire field is almost totally unexplored the author hopes that this study will show a better understanding of how speed is attained on the ice, and to make way for further research in this field.

Time is an important factor in competitive skating as well as in ice hockey. As in most of the unexplored athletic fields there is obviously a need for training techniques that require little time to administer, and also produce results conducive to increased skating speed.

Purpose of the Study

The main purpose of this study was to determine whether or not a leg strength program oriented specifically to the skating sprint has a place in the regular training procedures for competitive skating sports.

In order to realize this purpose, three main objectives were selected: (a) to determine the correlation between leg strength and the skating sprint, (b) to determine the effect of increased leg strength on the skating sprint, (c) to develop a leg strength training program

that requires a minimum of equipment, time, and financial support.

Limitations of the Study

The effectiveness of the training program was limited by three factors: (a) the amount of time available for the programs administration, (b) difficulty in preventing the subjects from missing the training sessions, and (c) difficulty in motivating the subjects to perform maximally in the experiment.

No attempt was made to control any of the subjects outside the training program and the testing periods.

There was not enough available time or money to include more initial and final tests. It would have added to the study to have tested at the end of every week of the training program in order to establish a curve that would project improvement patterns.

Definition of Terms

Leg Strength

A representative measure of leg strength was taken with a dynamometer. This refers only to the strength of the hip extention, knee extention and plantar flexion.

Average Velocity

Average velocity, which was measured in both the initial and final tests was determined with the aid of an

electric timer. The subjects had to skate a distance of 120 feet, from the goal line to the second blue line on the hockey rink.

CHAPTER II

REVIEW OF THE LITERATURE

Since there is no research dealing with skating in the literature this chapter will chiefly concern itself with leg strengthening programs. It will be necessary to consider the several types of training programs under different headings.

Characteristics of Dynamic and Static Strength Development

Goldenberg (15) expressed the following thought concerning progressive weight training: "A muscle developed over a long period of time remains in good condition for a long time, and a muscle developed through heavy weights with few repetitions lasts a short time." Thus, he suggests that light weights be used and that three bouts of ten or fifteen repetitions is sufficient for developing long range strength.

Burnham (10) maintained that one-half of the maximum load will stimulate growth of muscles. Berger (2) found that lifting once a week produced a significant increase in strength. In another study Berger (4) found that three to nine repetitions maximally to be the optimum number of repetitions with which to train for quickest strength improvement.

In a study by Mathews and Kruse (21) a group of subjects trained statically by exerting three consecutive six-second maximal static pulls on a strap. The number of practice sessions per week was different for each group but not less than two or more than five times a week. The results showed that individuals reacted to static strength training in an independent manner. It is interesting to note that as the frequency of the exercise was increased from two to five times a week, a greater number of subjects gained in strength.

In one of the earlier investigations of isometric exercises Hettinger and Muller (17) found that one daily exercise in which tension was held for six seconds resulted in as much increase in strength as did exercise that involved longer periods and more frequent practices.

Rasch and Morehouse (26) reported insignificant gains in elbow flexion strength following a six-week training program which included only three training sessions per week. Each training session consisted of three two-thirds maximal contractions with a three minute rest between each contraction. These same training techniques resulted in a significant increase in arm elevation length.

In a summary of some of the literature on isometrics, Wagner (28) reported that "researchers recommended that the duration of the strain be about six seconds." "It is also recommended that from one to three bouts of each exercise be done daily, using about 75% of maximum effort."

Rarick and Larson (24) supported the Hettinger-Muller hypothesis of static strength development. Their data showed that tension levels greater than two-thirds maximum with more frequent exercise bouts were not superior to a single daily six-second bout in increasing isometric strength.

Effects of Strength Training on Muscular Speed and Endurance

In an attempt to determine the effects of static and dynamic strength on muscular strength and endurance, Dennison, Howell and Morford (12) found that both static and dynamic training programs produced statistically significant improvement in strength and muscular endurance of the upper arms.

In a similar study, Howell, Kimoto and Morford (18) found approximately the same results. They hypothesized that "increases in muscular endurance may be effected by certain programs of isometric contractions as well as isotonic exercises."

Chui (11) compared a weight training group to a group in a required physical education class in an attempt to ascertain the effects systematic weight training had on athletic power. The Sargent jump, the eight and twelve pound shot put and the sixty yard dash were used as criteria. It was concluded that the weight training group improved in muscle power over the control group and that the results

indicated that speed could probably be increased through systematic weight training.

Gray, Start and Walsh (16) found a correlation of .470 between leg speed, as measured by the bicycle ergometer, and leg power, as measured by the vertical jump. The investigators mentioned that compared to other similar studies, this correlation was somewhat low.

It was the intent of Wilkin (29) "to test the hypothesis that training with exercise of the heavy resistance type causes an incipient muscle-bound condition, defined in part as impaired speed of movement." In order to test this hypothesis, speed of movement of the arm action was tested before and after resistance training. The conclusion was that over a period of one semester, weight training had no slowing effect on speed of arm movements.

Zorbas and Karpovich (31) conducted a similar experiment to determine whether weight lifting would have a slowing or speed-effect on the rate of arm movement. It was their conclusion that in rotary arm motions the weight lifting group was faster than the non-lifting group.

Effects of Static Strength and Dynamic Programs on Leg Strength

Strength gains of high school boys in a static training program were studied by Wolbers and Sills (30). The subjects involved met five days a week and, in performing the static exercise, the contraction was held for a period

of six seconds once a day. They concluded that, for the hip and knee extensor muscles, "static muscle contractions of six seconds' duration will cause significant gains in strength." The increase in leg strength was not enough to produce a statistically significant gain in the vertical jump.

In an article concerning the explosive power of athletes, Steitz (27) cited several reports concerning the development of leg strength by using an overload training program. A general conclusion drawn from these articles was that a five week weight training program was sufficient to significantly improve vertical jump and leg strength. He also suggested that heel raises and deep knee bends with an application of the overload principle were two very good exercises for increasing leg strength.

An article on general weight training by Goldenberg (15) referred to a list of nine suggested exercises to be used as a pre-season training program. Among these exercises were two designed to produce increases in leg strength: (a) the squat and (b) heel raises. He suggested several repetitions with lighter weights in order to produce strength that will be retained longer.

Brown and Riley (8), in an attempt to determine the effect of weight training on leg strength, used a weight training program of five weeks duration to train one group of a matched sample while the other group did not train

at all. A simple heel raising exercise with weighted bar bells on the subject's shoulders was used to increase leg strength. From the results it was concluded that a five week weight training program using only the heel raising exercise will increase leg strength, and consequently, vertical jump.

Berger (3), in another study, concluded that significant increases in strength would occur after only two weeks of training twice weekly with two-thirds or more of the 1-RM, provided at least one maximum dynamic effort per week was performed.

Berger and Blaschke (5) found that leg power, through his test, was significantly more related to dynamic strength than static strength (p. at .01). Berger also reported that dynamic strength was more related to motor ability than static strength. Berger (7) further found a correlation coefficient of .71 between leg strength and leg power.

Berger and Hardage (6) concluded that the weight training program, employing maximum or near maximum loads for each of ten repetitions, was more effective for increasing strength than a program involving the performance of 10 repetitions with the 10-RM, among lifters with no previous lifting experience and when training occurred three times weekly for eight weeks.

Morehouse (23) concluded that the degree and rate of strength development was about the same for groups of

subjects with different initial strengths when, one, three, five or ten contractions were performed in training sessions held four times each week.

Measuring Leg Strength with a Back and Leg Lift Dynamometer

Hubbard and Mathews (19) decided that leg lifts measured with a back and leg dynamometer without the use of a belt could involve factors other than the ability to lift with the legs.

Everts and Hathoway (13) found the same results and suggested several ways in which the belt helped performance, by increasing the accuracy of measurement, increasing the confidence of the subject, and by increasing safety.

CHAPTER III

METHODOLOGY

Experimental Subjects and Sampling Method

For the purpose of this study the experimental population was defined as freshman males between the ages of eighteen and twenty who participated in hockey as a competitive athletic event.

Permission was granted by the Michigan State hockey coach to use his entire freshman squad as a representative sample of this population. His squad consisted of sixteen men between the ages of eighteen and twenty, all of whom were enrolled as freshmen at Michigan State. There was a wide range of hockey skill and ability represented in the group.

The experimental group consisted of eight subjects which left eight men in the control group. In order to match the groups evenly, the subjects were ranked alternately according to skating speed into control or experimental group.

Experimental Design

Both the experimental and the control groups received initial tests to determine average velocity and leg strength. For six weeks following the initial test, the control group

participated exclusively in the regular practice sessions as directed by the coach of the team. During this same six-week period, the experimental group engaged in both the regular training program and the experimental training program. At the end of six weeks both groups were tested again. The final tests were identical to the initial ones, testing both leg strength and skating velocity.

Testing Procedure and Equipment

Leg Strength

A back and leg dynamometer was used to obtain a representative measure of leg strength. As stated by Mathews (20), this was one of the most difficult strength tests to administer. A slight variation in the angle formed by the femur and the tibia-fibula can produce a marked difference in the related measure of strength. The method of adjusting this machine to the individual does not provide an accurate means of regulating this angle. Thus it is possible that the dynamometer does not record true leg strength. But, for the purpose of this study a representative measure was deemed sufficient to demonstrate any significant change in leg strength.

Leg strength was measured in the same manner for both the initial and final tests. All the subjects were given a chance to try the testing apparatus once to become familiar with the correct procedure. In this practice lift, each

person was asked not to lift maximally to eliminate the possibility of fatigue. For the actual test each man lifted maximally only once at the approximate angle of 130 degrees.

The dial units of the particular piece of apparatus used were not a common unit of measure. Thus, the machine was calibrated and all scores were measured in pounds.

Average Velocity

Average velocity, which was measured in both the initial and final tests, was determined with the aid of an electric timer. The distance the subjects had to skate was 120 feet, from the goal line to the second blue line. The subjects were individually lined up on the goal line and on signal skated as fast as possible to the second blue line. As the judge gave the signal he simultaneously pressed the button to start the timer, and when the subject crossed the blue line at the finish he had to break a string that was attached to a circuit breaker which stopped the timer.

All the subjects in the experimental group were timed three times for the initial and three times for the final test. A mean velocity was determined for each subject for both the initial and final tests.

Experimental Training Program

Procedure

The training program began immediately after the initial test. At the end of six weeks the final test was administered. The training sessions were held on Mondays, Wednesdays and Fridays to eliminate conflicts with the team's scheduled games and scrimmages. In addition to the experimental training program, each subject participated in the regular daily practice just as did the control group.

Equipment

The apparatus necessary for the training consisted of a set of barbells and two hard rubber mats. A piece of sponge tubing was placed around the middle of the bar to prevent soreness while the exercise was being performed with heavy weights (Figure 1).

Exercises

The training program consisted of one exercise designed to increase leg strength from complete dorsal to complete plantar flexion. Specifically, the exercise was a half squat with weights over the shoulders of the subject. The individual was standing so that the phalanges and metatarsals of the feet were supported by the hard rubber mats that measured three inches high. The heel of each foot was extended beyond the edge of the mats. Thus, the

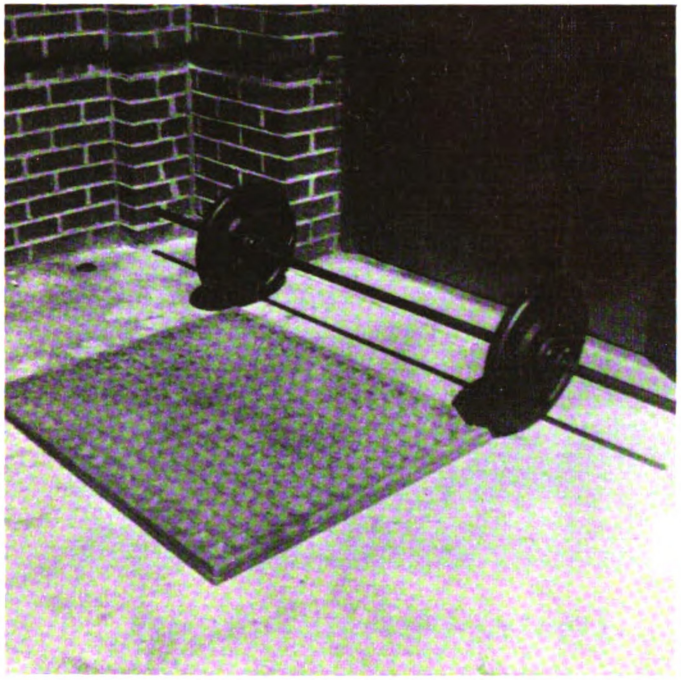

Fig. 1.--Exercise equipment.

supported weight was raised with concentric plantar flexion of each foot. Subsequently, the supported weight was lowered slowly by an eccentric contraction of the plantar flexor muscles.

The range of motion was from an extreme plantar flexed position to an extreme dorsal flexed position where the heel was lower than the horizontal plane of the mats (Figures 2 and 3).

During the first training period each subject lifted 150 pounds of weight. Each week 25 pounds was added to the weight, and at the end of the six week training period

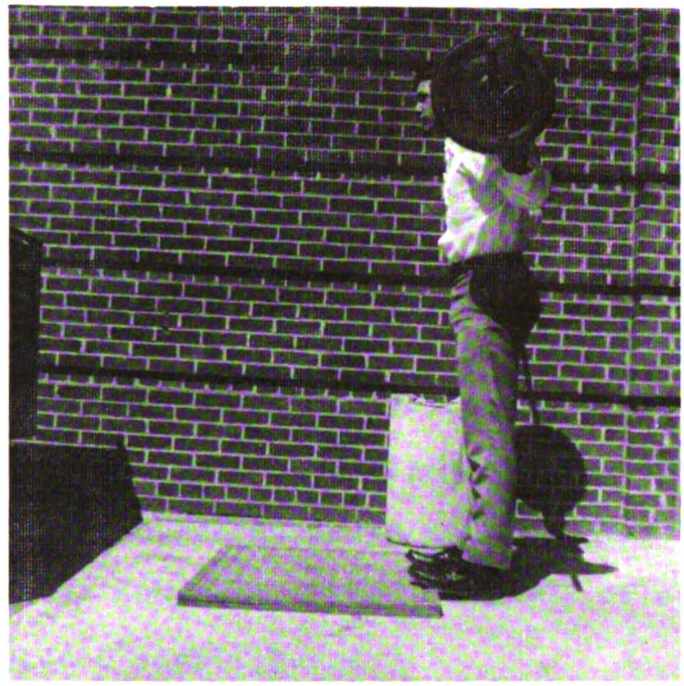

Fig. 2.--Exercise (start).

Figure 3.--Exercise (finish).

a maximum of 275 pounds was reached. As each subject did as many repetitions as he could, repetitions increased on an individual basis.

Statistical Method

The Pearson product moment correlation coefficient was used to correlate leg strength with skating speed. The t-test for determining the difference between mean changes was used to test for the significance between the improvement of the control subjects and the improvement of the experimental subjects. The .05 level of confidence was used to indicate significance.

CHAPTER IV

PRESENTATION AND ANALYSIS OF DATA

Correlations

Leg strength and skating speed were compared and a correlation of -.180 was obtained.

The Effects of the Training Program on Leg Strength

Using the t-test for determining the difference between mean changes, the improvement of the leg strength of the control subjects was compared with the improvement made by the experimental subjects. It was discovered that there was a significant difference at the .05 level in favor of the experimental subjects. This result supports the effectiveness of the training program developed for this investigation (Table 1).

TABLE 1.--Improvement of leg strength from initial test to final test in the control and experimental groups.

Group	Pre and Post Mean Strengths (lbs.)	
	Initial	Final
Control	212.5	213.8
Experimental	218.3	237.9
Difference	4.2	24.1

ltl = 1.90*

The Effects of the Training Program on Skating Velocity

Using the t-test for determining the difference between mean changes, the improvement of the skating of the control subjects was compared to the improvement made by the experimental subjects.

There was no significant difference between the mean average velocity of the control group and the mean average velocity of the experimental group for either the initial or final tests.

TABLE 2.--Improvement of the average velocity from initial to final tests in the control and experimental groups.

Group	Pre and Post Average Velocity (secs.)	
	Initial	Final
Control	5.11	5.12
Experimental	5.13	5.15
Difference	- .02	- .03

$|t| = -.05$

The increases in leg strength did not seem to affect the average velocity of their skating speed. Thus, the particular training program devised for this study may not be effective in increasing skating velocity.

Two of the experimental subjects received injuries during the training period and had to suspend their exercises for a short period of time.

CHAPTER V

DISCUSSION, SUMMARY, CONCLUSIONS, AND RECOMMENDATIONS

Discussion

The low correlation may be partially the result of an indicated lack of motivation in the subjects involved. Also, the skating sprint in the test may rely heavily on the reaction time of the subject as well as his leg strength. Perhaps, if body weight had also been included as a factor in the computation of the correlation, a higher value would have been obtained.

One possible explanation for the lack of a statistically significant change in velocity and a low correlation found in this investigation is the lack of motivated subjects. Several of the subjects, particularly in the experimental group, were not highly motivated to participate in the experiment. With the groups as small as they were, three or four poorly motivated subjects might have a negative influence on the results of the investigation.

Summary

The purpose of this study was to determine whether or not a leg strength program, oriented specifically to

skating speed, has a place in the regular training program for athletic skating events.

The need for such a study is indicated by the lack of literature concerning the effects of strength training on skating speed in particular and on competitive ice sports in general. The possibility that an increase in leg strength would increase skating speed was the main motivation for this study.

A leg strength training program was devised which required little time and a small amount of financial support. After initial tests for leg strength and average velocity were administered, a sample of sixteen available subjects was alternately divided into control and experimental groups of eight each. The experimental group participated in the leg strength program for a period of six weeks. During this same six-week period, both the control and the experimental groups participated in the regular hockey training program. At the end of six weeks both groups were tested for leg strength and average velocity.

Leg strength was measured by a back and leg dynamometer. Average velocity was measured by the use of an electric timer. Each subject skated a designated distance three times and then a mean was computed.

Leg strength and skating time were compared and a correlation of -.180 was obtained.

The experimental group showed a statistically significant increase in leg strength at the end of the six-week training program. Velocity did not improve significantly from the initial test to final test in either the experimental or control group.

Conclusions

1. The leg strength program described in this study did produce a significant increase in leg strength at the .05 level in six weeks or less.

2. The increase in leg strength did not produce any significant increase in velocity at the .05 level.

It is possible that a much larger increase in leg strength is necessary to significantly improve velocity. There may be other basic skill factors, such as reaction time, that were not measured in this experiment, that combined to off-set the leg strength improvement.

Furthermore a similar increase in leg strength in a larger segment of the total population might result in a corresponding increase in skating velocity.

3. A significant increase in strength did not have an inhibitive effect on skating velocity. This was in agreement with other studies that have shown that weight training and strength increases did not have a slowing effect on speed of muscle contraction (29, 31).

The correlation computed in this report for leg strength and average velocity of skating speed, -.180,

may be misleading and might have been higher if appropriate variables, such as weight, were controlled.

Recommendations

1. This study should be repeated or a similar study conducted with a better motivated, better controlled sample. In a future study the effect of body weight on leg strength and average velocity should be considered.

2. A study should be conducted concerning the reaction time of the skaters in connection with their speed for a given distance.

3. A similar study should be conducted with subjects using a uniform starting stance for their start.

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APPENDIX

APPENDIX I.

Name and Number	Height	Weight	Age	Group	Initial Testing Times (in sec.)		
					Trial 1	Trial 2	Trial 3
Bingham #2	5'7"	150	18	Control	5.43	5.27	5.39
Kastys #3	6'1"	175	18	Exptl.	4.92	4.86	5.02
VonGruben #4	5'11"	165	18	Control	5.26	5.34	5.32
Lansky #5	5'9"	180	20	Exptl.	4.96	5.11	4.93
Charest #6	5'10"	175	19	Control	5.10	5.00	5.01
Finegan #7	5'11"	170	19	Exptl.	5.03	5.22	5.43
Gosselin #8	5'10"	150	18	Exptl.	5.20	5.39	5.41
Clements #9	5'10"	170	18	Exptl.	5.36	5.28	5.27
Malcombson #10	5'11"	195	18	Exptl.	5.15	4.96	4.98
Sokoll #11	5'10"	184	19	Control	4.70	4.72	4.88
O'Connor #13	6'0"	181	20	Control	5.30	5.24	5.26
M. DeMarco #14	5'11"	174	20	Exptl.	5.00	5.31	5.22
Houtteman #15	5'10"	163	18	Control	5.20	5.01	5.20
Maier #16	5'11"	187	19	Exptl.	5.07	5.10	5.09
J. DeMarco #17	5'11"	179	19	Control	4.93	5.13	5.00
Schmidt #18	5'6"	130	18	Control	5.00	5.12	4.93

Mean Times (sec.)	Leg Strength (lbs.)	Final Testing Times (in sec.)			Mean Times (sec.)	Leg Strength (lbs.)
		Trial 1	Trial 2	Trial 3		
5.36	189	5.29	5.37	5.34	5.33	193
4.93	212	5.01	5.03	4.97	5.00	233
5.30	221	5.34	5.36	5.30	5.00	221
5.00	234	4.87	5.10	5.03	4.96	257
5.08	229	5.21	5.00	5.04	5.03	222
5.22	203	5.30	5.18	5.22	5.23	224
5.35	228	5.21	5.44	5.41	5.30	247
5.31	196	5.37	5.28	5.29	5.30	219
5.03	219	5.11	4.99	5.06	5.05	231
4.76	221	5.01	4.83	4.79	4.91	227
5.26	232	5.22	5.31	5.34	5.29	229
5.17	237	5.27	5.19	5.15	5.30	253
5.13	201	5.23	5.17	5.11	5.17	211
5.08	217	5.10	5.04	5.06	5.08	239
5.03	222	5.00	5.20	5.00	5.08	218
5.01	185	5.08	5.04	5.00	5.07	191

A. S. Paige 1968
M.A.