Master's Thesis
HPER 593

Linking Strength With Speed

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CHAPTER 1

THE INTRODUCTION

Introduction

The popularity of running as its own sport as well as a critical element to other sports has lead many researchers to investigation. More specifically, researchers have sought to understand ways in which running speed can be enhanced; thereby giving rise to greater performance levels. For many years, it was believed that there was no direct link between increased muscle strength and increased speed. This was directly related to the belief that running was more of an isokinetic activity that did not require substantial amounts of force.

The recognition of the propulsion factor, which is the number of times the foot hits the ground combined with the ability of the leg, hip flexors and knees to propel the individual forward, has shown direct relations between leg muscle strength and speed. Weight training is one popular way to increase overall muscle strength, and this study supports the use of weight training as a means of increasing leg muscle strength in non-professional runners. This study was created to demonstrate the link between greater muscle strength, achieved through weight training, and increased speed in non-competitive runners. By demonstrating first that weight training results in stronger muscles and then that these muscles are utilized in increased propulsion force that increases speed, this study supports the theory that speed and muscle strength are directly related.

The Problem

Many runners have attempted to increase their running speed through various aspects of running. There appears to be limited knowledge, among non-professional runners, linking muscle strength with speed.

Purpose of the Study

The purpose of this study was to demonstrate the effect of muscle mass and muscle strength training on speed in a 50-meter sprint. Though current literature supports a non-linear correlation between improved muscle strength and increased endurance and distance speeds, the link between increased muscle strength and sprinting speeds has little direct documentation.

Assumptions

There were several assumptions that were necessary to address before beginning this study. The first major assumption was that increases in muscle mass due to increased weight training result in increased muscle strength. The second assumption was that weight training increases muscle strength in the leg muscles. The third major assumption was that the participants of the study provide accurate reflections of their weight training participation during the course of the study. The final assumption was that there are no adverse affects relating to the long-term use of weight training in regard to overall speed performance, as this study was conducted over a two-week period.

Limitations

This study was limited to a population consisting of males age 16-40 years who were active runners; in order to provide the greatest degrees of similarity and overall efficacy for the information provided, without adding additional variables, including gender. The study was also limited to a time constraint of two weeks, and does not reflect the results of long-term use of weight training in increasing speed. Because of the need to determine commonalty between participants and reflect an initial lack of professional weight training, this study was conducted within a group of non-professional runners.

Delimitations

The delimitations of this study included the following: males 16 - 40 years of age, three running clubs in the Conejo Valley area of Southern California, a time constraint of two weeks, a specific weight training regimen, and the selection process. All these delimitations were directly controlled by the design of the study.

Operational Definitions

Non-professional runner is a person who participates in running activities and may even compete in running competitions, but does not train for or compete in running events on a professional level. For the purpose of this study, the participants were chosen from running organizations, suggesting an aptitude for running at the onset. **Muscle strength** refers to the ability of the muscles to generate maximum force production. **Power** is defined as the ability to produce force at a high intensity for a brief period of time. **Speed** refers to the ability of an individual to run from point "A" to point "B" in a measured amount of time. **Fifty-meter sprint** was the standard run utilized in this study to judge increased speed performance after weight training.

Conceptual Definitions

Increased performance was measured by increased speed, but also recognized decreases in overall injury rates, which directly impacts speed. The evaluation process utilized in this study considered both speed and injury and judged increased muscle strength through resistance weight and lift procedures.

Research Hypothesis

There will not be a significant difference between the means of the experimental group and control group.

CHAPTER 2

REVIEW OF RELATED LITERATURE

Theoretical Framework

The theoretical framework of this study was based on the significance and value of weight training on increasing muscle strength, muscle mass, and increasing running speed for non-professional athletes. Current literature demonstrates that runners who are not utilizing muscle strength to its fullest potential risk the possibility of injury and that the use of weight training to increase speed is one way in which a runner can increase performance while decreasing the chance of injury.

Literature Review

The current literature supports the suggestion of a non-linear connection between the increased muscle strength and increased speed for runners. It is clear that from an experiential basis, many runners have discussed their belief in effective changes in their running speeds due to increased training, but scientific methods are necessary to evaluate the link between increased weight training and speed (Bobbert & Van Soest, 1994). There is considerable support on an anecdotal level for the relationship between increased muscle strength and greater propulsion force (Anderson, 1997). "Running easily in daily runs, does not increase power, but increasing leg muscle strength and learning to produce propulsive force does. These factors reduce foot strike time, and less time with the foot on the ground increases speed" (Anderson, 1997). Though weight training has never been suggested as a means of increasing speed exponentially, many researchers contend that improved performance is one result of greater weight training to increase running efficacy. One of the main reasons for supporting increased muscle strength to increase speed is that increased leg muscle strength gives a runner a better push-off from the ground, and this increased power improves the length of individual stride. It has been suggested that a stride increase of just 2% can take 30 seconds off of the time it takes to run a 5K race (Anderson, 1997).

Power is defined as the combination of strength and quickness, and it is the increase in power that increases the stride of each runner. Scientists in Finland have experimented with strength training as a means of boosting maximal running speed and have demonstrated increases of as much as 10 percent. Because the efficacy of their running times by the use of weighted equipment during training sessions (Anderson, 1993).

The use of resistive equipment, including weighted vests and shorts has been utilized to improve speed in explosiveness for short distance athletes. The use of weighted shorts in training has demonstrated effectiveness through increasing the viability of flexors and extensors, the two muscle groups that sprinters rely on (Yessis, 1993). Heikki Rusko, a Finnish researcher, provided the first extensive study of the use of weighted vests on the biomechanics of running, and noted that the lactate production and threshold increased by 2 percent in athletes utilizing weighted vests. Endurance in sprinters increased by 25 % from the use of this weighted equipment over a two-week period (Anderson, 1993). Forward propulsion in running, one of the most important considerations in sprinting activities, is provided by the hip flexion, including the iliacus and rectus femoris muscles, during the early swing and knee extension during the late swing (Montgomery, Pink & Perry, 1994). Increases in the strength of these particular muscle groups would clearly improve the overall speed during sprinting.

A number of studies have demonstrated the increased oxidation capacity in skeletal muscles provided through the use of endurance exercise training. The findings of a study by McAllister, Reiter, Amann and Laughlin (1997) demonstrated a greater level of muscular oxidation, in providing the overall health and strength of individual muscle groups, which was demonstrated through strength training processes. It is also clear that there is a significant relationship between the work provided by leg muscles and the impact on individual joints. As a result, the transfers of power that occur during explosive leg extension impact muscle groups as well as joints, and these impact both speed and efficacy in sprinting (Jacobs, Bobbert, Van Ingene Schenau, 1996). The successful strengthening of the biarticluar leg muscles reduce the impact on joints, allowing for greater speed while also reducing the chance of joint injury due to significant impact (Jacobs, Bobbert, Van Ingene Schenau, 1996). One other benefit of long-term weight training is a reduction in the overall levels of fatigue for runners, changing the running kinematics and increasing overall performance levels in terms of both speed and injury reduction (Williams, Snow and Agruss, 1991).

It is clear that the literature supports a connection between increased performance and increased weight training, although Bobbert and Van Soest (1994) suggest that weight training must also be used in conjunction with personal skill improvements in order to prevent detrimental impacts on the improvement levels of athletes. Because weight training can change the way in which the body reacts to certain movements, it should be utilized in conjunction with standard exercise practices in order to support the greatest level of performance and speed increases.

The current literature supports the connection between muscle strength improvements and increases in running speeds, though there is little documented support for the correlation between muscle strength and increased sprint speeds in the 50-meter sprint. This study demonstrates this theoretical correlation through the use of weight training to increase muscle strength and the timing of 50 meter sprinting in order to demonstrate overall increases.

CHAPTER 3

PROCEDURES

The Setting

This research was an experimental design that used a control group, an experimental group, interviews, suggested weight training regimens and surveyed measures of time to support the literature research. This study was supported by experiential testimony of the participants, and reflects their progression over a two-week period.

The study took place at Agoura High School in Agoura Hills, CA. This site was chosen for its facilities and population of running clubs.

Population

The population targeted by this study was men between the ages of 16 and 40 years who were active runners. The subject population was selected from 3 running clubs, and the subject populations were limited to those runners who did not actively participate in regular weight training activities. Those runners were also asked whether they participated in running activities on a professional level, and a number of possible subjects were disqualified because of their participation as professional runners. Of the 50 men that were selected randomly from the given population, only those who fit the given criteria were chosen for the study. Those who were chosen were then randomly divided into two groups; a control group and an experimental group.

The running club organizations used to locate possible participants were selected with necessary regional considerations, because of the necessity for personal interviews in the process of determining muscle strength and pre-training speeds.

The rationale behind the sampling method was designed to select a population that best met the necessary criteria while also providing for some randomness in the process.

Both the control group and the experimental group were initially interviewed, surveyed and then surveyed again after a two-week period. At the time of the initial contact, the researcher took initial self-reported data in regard to muscle strength, speed, and weight training activities that the subjects may have participated in on a sporadic basis.

Research Design

The research design used in this project was quantitative. The independent variable in this study was the prescribed strength-training regimen. The dependent variables in this study were the individual speeds or splits for the 50-meter sprint.

The extraneous variables identified in this study were:

1. The running club organization environments
2. The physical and emotional condition of the subject
3. The receptivity of the subject to the survey
4. The perception the individual had toward the success of the process
5. The ability of each individual to provide accurate self-reports in regard to their weight lifting activities.

Internal Validity

Internal validity was by addressing several issues or concerns that could have possibly compromised the causal relationship. These threats fell into seven major categories: History, Maturation, Testing, Instrumentation, Regression, Mortality, and Selection.

External Validity

The external validity of this study was to depend on participant representation and report. Initial feelings were that the results of this study might not be externally valid in that they may only apply to the situations that the study was administered.

Instrumentation

The instruments used in this study were:

1. A survey that utilized question formats to illicit the greatest response among people of differing cognitive abilities.
2. A specifically designed weight-training regimen.
3. A record sheet for recording results for each participant.
4. A Seiko hand timer.

Treatment of Data

The data collected from this study was used to determine any significant differences between the control group and the experimental group. Statistical methods were used in determining these differences. The analysis of variance (ANOVA) procedure was used in determining variations in the means of each group.

Running Survey

The following is a brief survey consisting of several questions about your running. This survey is the initial step of a study being conducted by a graduate student from Adams State College in Alamosa, CO. The results of this study will be used to examine several aspects of running speed as they may relate to muscle strength. All information on this survey will be kept strictly confidential.

Please circle or fill-in the most accurate response to each question.

1. What is your first name and last initial?	____________________	
2. What is your correct gender?	Male	Female
3. What is your present age?	__________	
4. Have you been running consistently for 2 or more years?	Yes	No
5. Have you been running consistently for the past 8 weeks?	Yes	No
6. Have you ever competed professionally in running?	Yes	No
7. Would you classify yourself as a distance runner?	Yes	No
8. Have you ever competed as a sprinter?	Yes	No
9. Have you ever worked-out with weights?	Yes	No
10. Have you ever followed a specific weight-training routine?	Yes	No
11. Are you presently involved in a weight-training routine?	Yes	No
12. Do you have any present or past ailments that would affect your participation in a weight-lifting regimen?	Yes	No
13. Would you be willing to complete a two-week weight training program designed specifically for the purposes of this study?	Yes	No

Running Study
Prescribed Weight Lifting Routine

The prescribed weight-training routine must be done every other day for the entire period of two weeks. The following days will be your lift days: Monday, Wednesday, Friday, Sunday, Tuesday, Thursday, Saturday. Please do not miss any days. If you do miss a day, please make a note of it.

The following exercises should be done at a weight in which you can complete 8-10 repetitions. Each exercise will be done in two sets on Monday and Wednesday and three sets on all days that follow.

1. Bench Press
2. Lat Pull
3. 5lb Weighted Arm Swing
4. Hamstring Curls
5. Leg Extensions
6. Sled
7. Calf Raises
8. Lunges

CHAPTER 4

THE DATA

Data Analysis

This study compared the results of two groups of non-professional distance runners. These groups were divided into a control group, which maintained their normal training routines, and an experimental group, which added a weight lifting program to their normal training routines. Each group consisted of 10 male runners between the ages of 16 and 40 years. Each participant was selected based on their response to a written survey. After this selection each participant was then randomly assigned a number and placed into either the control group or the experimental group (i.e., C1- C10, or E1- E10).

The initial test of all participants took place on a dirt track at Agoura High School in Agoura Hills, CA. Each member of both the control group and the experimental group was tested three times in a 50-meter sprint with full recovery between sprints (approximately 10 minutes). The best time from each of the participants (10 per group) was used in determining the mean time of the group. That mean was then used to determine the standard deviation. This exact procedure was used again for the final test of this study. These statistical methods helped us to determine any significant differences between the groups' means.

Of the 20 runners participating in this study, 12 showed an increase in their speed over the 50 meter trial, 4 showed a decrease, and 4 stayed the same (Table 1). Of the 10 runners in the control group, 3 showed an increase in speed by .1 seconds, 1 showed an increase in speed by .2 seconds, 1 showed an increase in speed by .6

seconds, 3 showed a decrease in speed by .2 seconds and 2 showed no change (Table 2). The mean value for their 50-meter sprint was 8.1 seconds initially and 8.0 seconds in the final test. The control group also had an initial standard deviation of 0.6 and a final standard deviation of 0.6 (Tables 4 and 6)

Of the 10 runners in the experimental group, 7 showed an increase in speed by .1 seconds, 1 showed a decrease in speed by .1 seconds and 2 showed no change (Table 3). The mean value for their 50-meter sprint was 8.1 seconds initially and 8.1 seconds in the final test. The experimental group also had an initial standard deviation of 0.5 and a final standard deviation of 0.5 (Tables 5 and 7).

Interpretation

Findings reported in Tables 1 - 7 give some indication that there was no significant difference between the control group and the experimental group. Both groups showed some increases in speed over 50 meters and although the experimental group showed more individual increases in speed, the mean performance time stayed the same.

Further analysis using the analysis of variance (ANOVA) procedure indicated that the *F* ratio (Table 8) was about 1 and that the null hypothesis was therefore correct. This interpretation was determined by the explanation that follows:

The likely range of variation of the averages if our null hypothesis was correct, is given by the standard deviation of the estimated means:

$$\sigma/N^{1/2}$$

Charts and Graphs

Table 1

Combined Group Performance Results

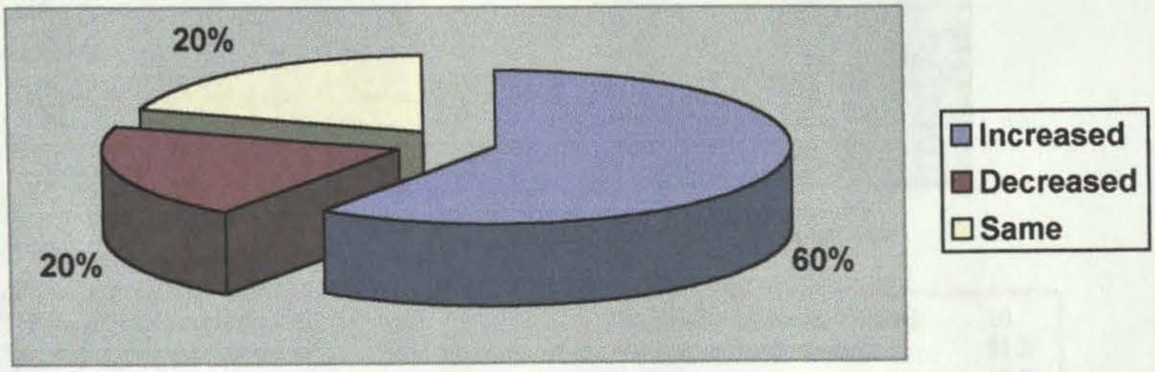


Table 2

Control Group Results

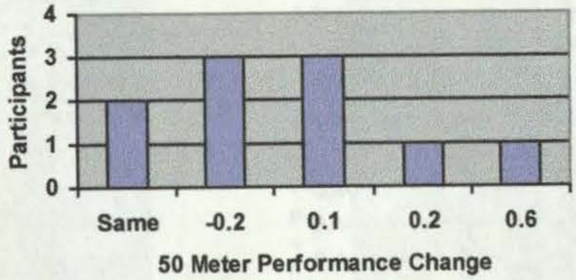


Table 3

Experimental Group Results

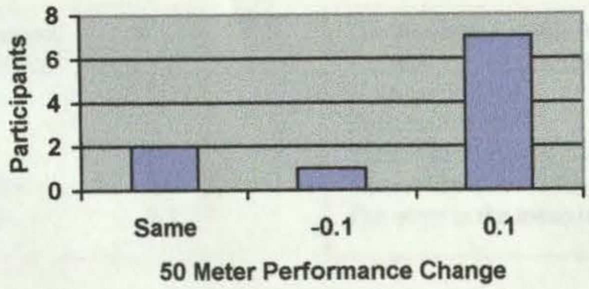
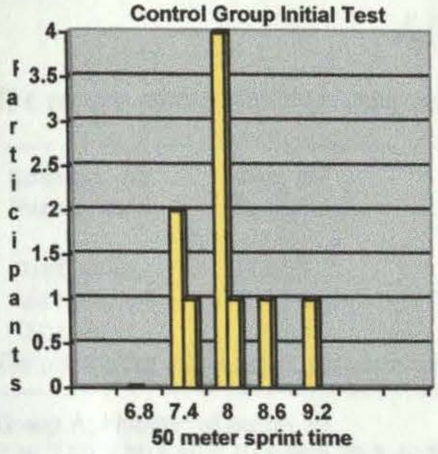
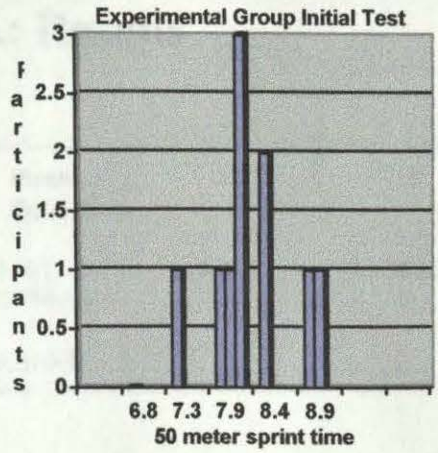


Table 4



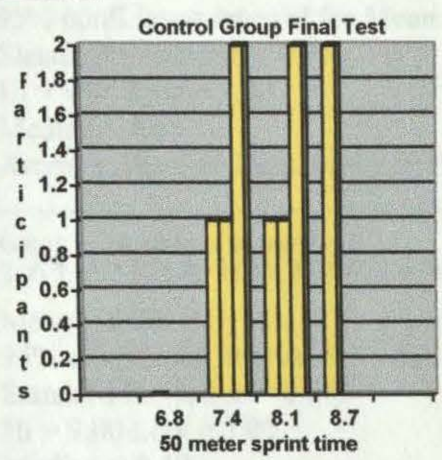
The number of events entered:	10
The sum of these numbers is:	80.7
Their minimum is:	7.0
Their maximum is:	9.1
Their mean value is:	8.1
The standard deviation is:	0.6
The error in the mean is:	0.2

Table 5



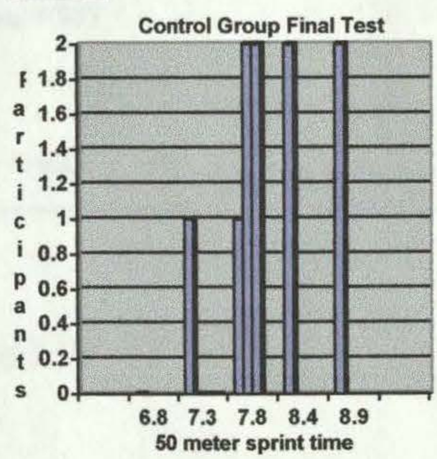
The number of events entered:	10
The sum of these numbers is:	81.2
Their minimum is:	7.0
Their maximum is:	9.0
Their mean value is:	8.1
The standard deviation is:	0.5
The error in the mean is:	0.2

Table 6



The number of events entered:	10
The sum of these numbers is:	80.2
Their minimum is:	7.0
Their maximum is:	9.0
Their mean value is:	8.0
The standard deviation is:	0.6
The error in the mean is:	0.2

Table 7



The number of events entered:	10
The sum of these numbers is:	80.6
Their minimum is:	7.0
Their maximum is:	8.9
Their mean value is:	8.1
The standard deviation is:	0.5
The error in the mean is:	0.2

Table 8

ANOVA: Results

The results of the ANOVA statistical test

Source of Variation	Sum of Squares	d.f.	Mean Squares	F	P
between	.0507	3	0.0169	.0465	0.984976
error	13.10	36	0.3638		
total	13.15	39			

The probability of this result, using the null hypothesis, is 0.986

Group A: Number of items= 10
7.00 7.20 7.70 8.10 8.10 8.20 8.20 8.40 8.70 9.10

Mean = 8.07
95% confidence interval for Mean: 7.683 thru 8.457
Standard Deviation = 0.636
Hi = 9.10 Low = 7.00
Median = 8.15
Average Absolute Deviation from Median = 0.450

Group B: Number of items= 10
7.00 7.80 7.90 7.90 8.00 8.10 8.30 8.40 8.80 9.00

Mean = 8.12
95% confidence interval for Mean: 7.733 thru 8.507
Standard Deviation = 0.559
Hi = 9.00 Low = 7.00
Median = 8.05
Average Absolute Deviation from Median = 0.400

Group C: Number of items= 10
7.00 7.40 7.50 7.50 8.00 8.20 8.30 8.40 8.90 9.00

Mean = 8.02
95% confidence interval for Mean: 7.633 thru 8.407
Standard Deviation = 0.663
Hi = 9.00 Low = 7.00
Median = 8.10
Average Absolute Deviation from Median = 0.540

Group D: Number of items= 10
7.00 7.70 7.80 7.90 8.00 8.00 8.20 8.30 8.80 8.90

Mean = 8.06
95% confidence interval for Mean: 7.673 thru 8.447
Standard Deviation = 0.546
Hi = 8.90 Low = 7.00
Median = 8.00
Average Absolute Deviation from Median = 0.380

where σ is the standard deviation of the participants scores from each group and N (10 in our sample) is the number of participants in a group. Thus if we treat the collection of the 4 group means as data and find the standard deviation of those means and it is "significantly" larger than the above, we have evidence that the null hypothesis is not correct and instead weight training has an effect. This is to say that if some (or several) group's average 50 meter sprint time is "unusually" fast or slow, it is unlikely to be just "chance".

The comparison between the actual variation of the group averages and that expected from the above formula is expressed in terms of the F ratio:

F=(found variation of the group averages)/(expected variation of the group averages)

Thus, if the null hypothesis is correct we expect F to be about 1, whereas a "large" F indicates a weight training effect. How big should F be before we reject the null hypothesis? P reports the significance level (Table 8).

Therefore, using ANOVA, the data collected in this study suggests that there is no significant change in speed for a 50-meter sprint after two weeks of prescribed weightlifting. This proves the null hypothesis.

CHAPTER 5

THE DISCUSSION SECTION

Summary

Of the 10 participants selected to be in the experimental group, only 4 had previously participated in sporadic weight training. As a result, the experimental group had to participate in a demonstration of the use of weight training equipment in order to demonstrate the greatest efficacy in results. The subject population was provided with a standard weight-training regimen, which included a goal of 5% increase in muscle strength by utilizing concentric and eccentric models of repetition to increase strength over the course of the two-week weight training section of the survey.

At the onset of the study, most of the subjects, 18 out of 20, described their personal physical condition as "fit" and did not consider the need for increased weight training, though all 20 subjects expressed willingness to attempt weight training as a means for increasing their muscle strength and increasing running speed. Similarly, all 20 participants claimed to have been running consistently during the past 2 years and for the past 8 weeks within those 2 years. Though none of the subjects stated that they could feel the change in muscle mass and no direct measurements were taken, one of the major assumptions provided in the study is that because no outside factors change significantly other than the implementation of the weight training program, changes in the running speeds can be linked to the changes in muscle strength that occurred.

Of the 20 runners participating, 12 demonstrated increases in their speed in the 50-meter sprint after two weeks. Of the 10 runners in the control group, 5 showed an increase in performance while 3 showed a decrease and 2 stayed the same. Of the 10 runners in the experimental group, 7 showed an increase in performance with 1 showing a decrease and 2 staying the same.

Of the 4 participants who experienced no increases and no reductions in their speeds, 3 did express the feeling of greater muscle strength. As has been suggested in the literature, continued application of weight training procedures could demonstrate greater improvements in their sprint times over a longer time period. Two of the subjects expressed concern for their feelings of fatigue and general muscle soreness, though these two subjects were members of the upper age range in the group, which may have been a factor in their gains. It should also be noted that all subjects participated in the same program, at the same place, at the same time, using the same equipment. As a result, this study was dependent on the accuracy of experiential data in supporting the validity of the information.

Major Findings

This study demonstrated that there is no significant gain in speed resulting from a prescribed two-week weight-training program. Of the 10 participants in the experimental group, all expressed an increase in their lifting force, directly related to the prescribed weight-training regimen. Since this number does not directly reflect the same number of speed improvements, there are factors that could have impacted the relationship between the increases in muscle strength, as measured through weight resistance, and increases in speed. These factors include the consistency of running training during the weight training procedures and the level of fatigue experienced by each runner during the timing of the 50-meter sprint during the follow-up process.

Conclusions

It is clear that there is no significant relationship between 2 weeks of prescribed weight training and an increase in speed over 50 meters. Although the literature supports a relationship between leg muscle strength and leg speed this connection must take place beyond the period of 2 weeks for non-professional distance runners in the Conejo Valley area of Southern California.

It should be noted that the literature also supports the efficacy of the speed and muscle strength correlation in long-distance runners, and that the use of the 50 meter sprint in this study may have reduced the overall perceptions of benefit as muscle strength can also be directly linked to greater endurance in all athletes.

It is also important to consider the time scope of the study in understanding its viability. Many weight-training experts have regularly contended that the greatest impacts of weight training are not immediately noticeable. Therefore, the two-week period necessary for the completion of the study may not reflect the long-term benefit of weight training in increasing sprint speed. In other words, because of the necessary brevity of the study, the most recognizable results of weight training may not have been seen.

Discussion

As running continues to grow in popularity as its own sport so to will the quest to find ways that allow humans to run faster. The sport of running has already seen many experiments and claims aimed at enhancing human performance levels. Some of these methods and experiments have given rise to greater levels of performance and some have just become gimmicks and ways to make money in our currently booming economy. Yet for most people the simple facts remain that in order to run faster or farther one must simply work harder and smarter. This study was aimed at those people who have come to accept these facts.

Though this study did not show any direct significance between weight training and sprinting over a two-week period, the general idea behind this study should not be discounted. Many other studies have been done that have shown great benefits to running through weight lifting and building muscle strength. The fact remains that speed and muscle strength may be directly related. However, this relationship may take longer than two-weeks to grow.

Recommendations

It is therefore recommended that distance runners interested in increasing their speed do indeed look into the ideas behind weight training. However, all considerations should be for a period longer than two weeks. As this study intended to demonstrate any relationship between weight training over a two-week period and increasing sprinting speed it did not discount any of the current benefits or claims to weight training. Rather this study showed that results from weight training as they relate to sprinting speed might not be evident within the first two weeks of beginning a new program. Although weight training is not the only means by which a distance runner can increase speed, current literature claims that it may be one of the safest and most effective programs to pursue. Current literature has also made many claims to the benefits of weight training in distance running as well as many other sports.

It would also be recommended that further research be done on this subject. Future studies might try a different weight-training regimen which consisted of more weight and less repetitions. Other suggestions would also include a co-ed study consisting of a completely random sample and varying time constraints beginning at three weeks.

As we know, this study was applicable to a small group of distance runners with varying ages in the Conejo Valley area of Southern California. It is therefore strongly recommended that these claims and results be examined in other settings with other participants.

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