THE EFFECT OF PLYOMETRIC AND WEIGHT TRAINING ON VERTICAL JUMP, STANDING LONG JUMP, AND SPEED IN THE 30-YARD DASH

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TABLE OF CONTENTS

Chapter | Page

LIST OF TABLES

LIST OF FIGURES

CHAPTER I

INTRODUCTION

Physical fitness can be divided into two categories: skill related fitness and health related fitness. The skill related components include the following: agility, balance, coordination, speed, reaction time, and power[27]. These are identified as skills which pertain to athletic ability in sports. Health related fitness is composed of cardiorespiratory endurance, body composition and musculoskeleted fitness which includes muscular strength[27]. Although the terms skill and health are separately defined by their components, most sports activities exist on a continuum between the two fitness categories. Therefore, if improvement in athletic ability is the goal of an individual, he or she must better understand the relationship between these components and design conditioning programs to improve the fitness components specific to his or her sport.

Power is one of the skill related components that coaches and researchers are concerned with improving. It is defined as work performed per unit of time and measured by the formula; work equals force times distance divided by time. Power is a combination of speed and strength.[18, 25, 27, 39]. By definition, increasing muscular strength will increase the amount of force capable of being applied by the muscle and thereby increasing power. Verhoshansky and Medvedyev[26] state that strength exercises ensure an increase in the power of the working effort of the athlete. Power is also increased by reducing the amount of time needed to complete a given amount of work (force times distance). This is accomplished by increasing the speed of movement.

One of the ways many coaches and researchers measure power is by testing an individuals' standing long jump and vertical leap. Pate and associates[28] state if dynamic muscular performance tests involve maximum total work performance within a short (nonfatiquing) time frame (e.g. vertical jump) then muscular power is being evaluated. Football is a sport that demonstrates the importance placed upon measuring the power of an individual for predicting future success in the game. Before drafting a player, a professional scout will test the players speed in the 40-yard dash, their vertical jumping ability, and their strength from a one repetition maximum lift (i.e., squat). These are some of the qualities of an athlete used as criteria to predict future success in many other sports as well. Since power is sports skill related, coaches and physical educators should employ within their conditioning routines the best training techniques to increase the subject's power producing ability.

The training programs observed in this study consisted of a weight training technique with free weights called the parallel squat and a plyometric technique called the depth jump.

Weight training is also called resistance training. It refers to forms of exercise involving the use of heavy loads with the primary goal to increase muscle strength and hypertrophy or both[4]. After an overload is placed on a muscle fiber, some fiber damage occurs. This damaged tissue will be repaired by increasing the rate of protein synthesis resulting in a bigger and stronger muscle fiber capable of defending against further destruction if a similar overload is placed on the muscle again. This hypertrophied muscle thus can do more work; it is stronger[20]. Because of this adaptability of the muscle to respond to an overload, a progressive weight training method will be employed which involves changing sets, repetitions and resistance. This method will be explained in detail under the review of literature and during the methods and procedures.

The weight training technique with free weights used in this study was the parallel squat. This is an isotonic exercise that involves no intervention by a machine or person to aid in balance or coordination of movement. A weighted barbell is placed on the lifter's shoulders. With the feet slightly wider than the shoulders, the lifter must flex at the knees and hips until the mid line of the thigh is parallel to the ground before returning to the starting position. Figure 1 (page 4) shows the proper squat technique. Bandy, Bandy, and Lovelace,[4] reported a study by Hakkinen, implemented a dynamic squat lifting exercise program, similar to the one in this study, designed to

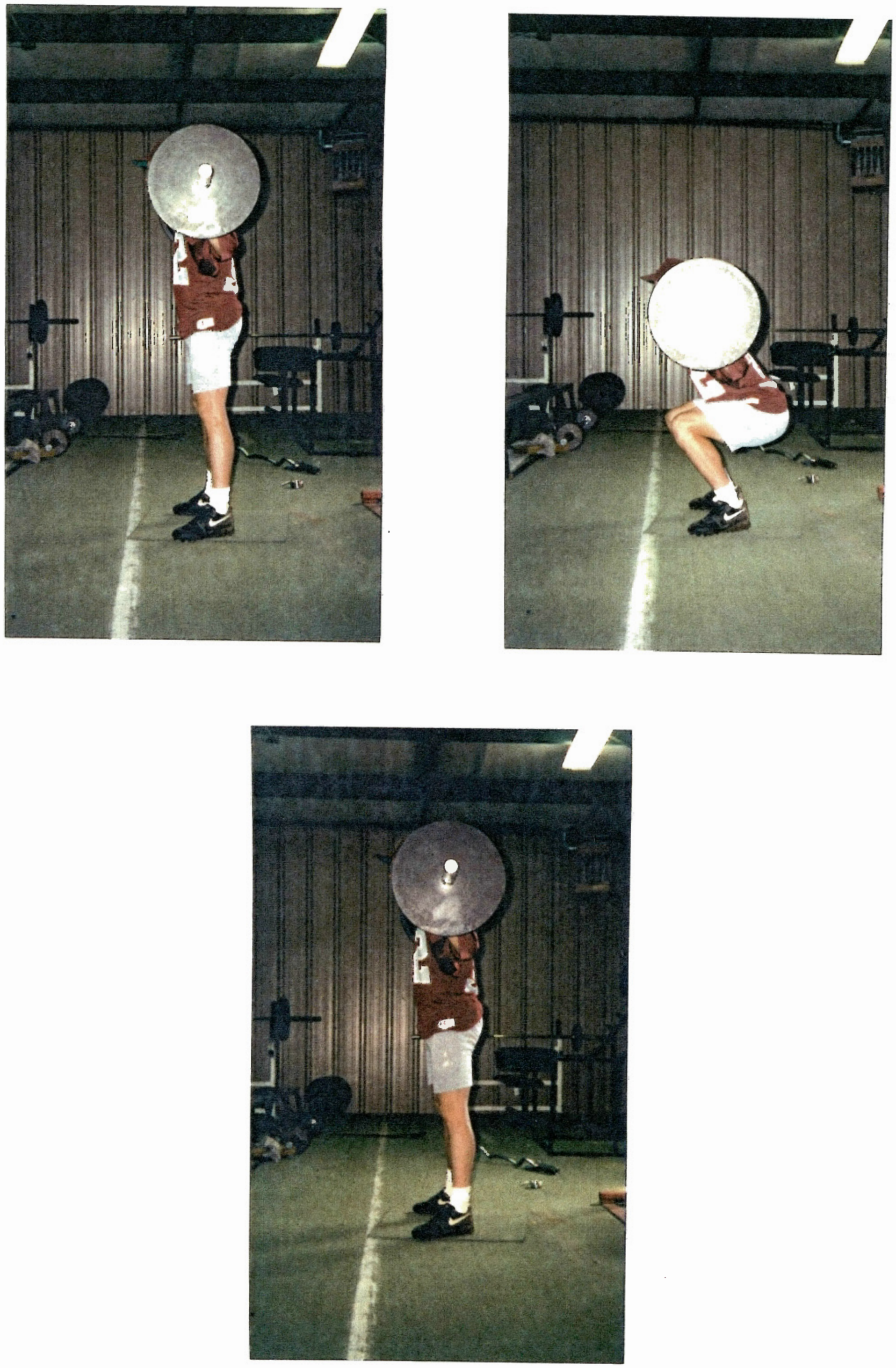

Figure 1. Parallel Squat

evaluate adaptation of the knee extensor muscles. Hakkinen revealed marked improvement in muscle strength and significant increases in neural activation of the motor units of knee extensor muscles as measured by electromyography.

The effects of a plyometric technique called depth jumps on the dependent variables was also observed. Plyometrics have rapidly become known as drills or exercises aimed at linking sheer strength and speed of movement to produce an explosive reactive movement often referred to as power[12, 13, 37]. Plyometrics are sometimes referred to as jumping drills. The premise of plyometrics is the stretch reflex. A rapid lengthening of a muscle, will result in a faster, more effective movement in the opposite direction[13]. Wilt[39] states that a stretch reflex specifies that muscles involved in any particular action will achieve a stronger contraction when preceded by a gathering phase involving the stretching (eccentric contraction) of such muscles. Plyometrics train the reactive ability of the nerve-muscle apparatus[35]. This reactive ability may be accomplished through depth jumping. A depth jump is executed by stepping off an elevated platform and, upon landing, immediately jumping into the air or onto another elevated platform with maximum effort. Figure 2 (page 6) represents proper depth jumping technique.

Purpose of the Study

The purpose of this study was to compare the effects of a weight training program and plyometrics on speed in the

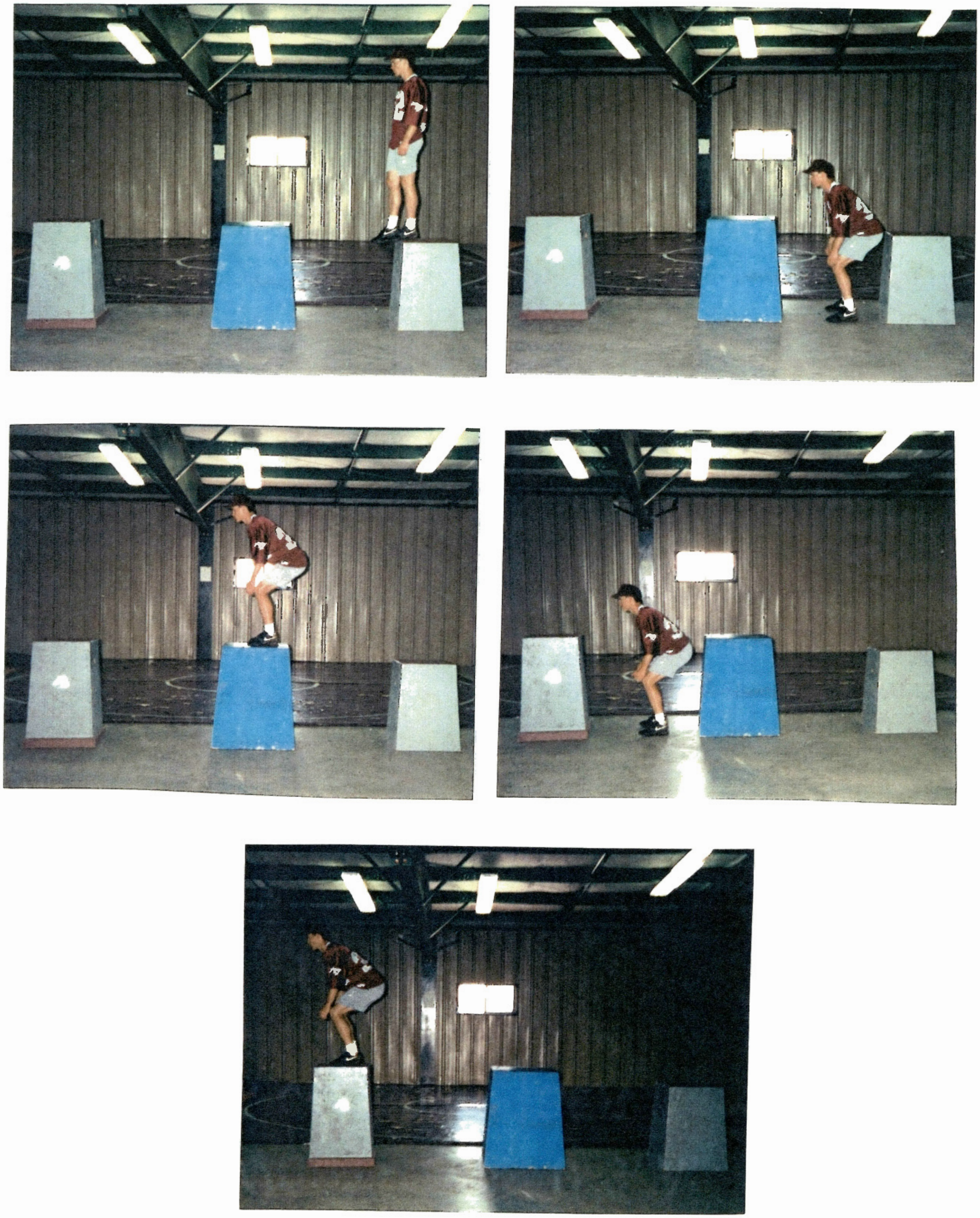

Figure 2. Depth Jump
1 Repetition

30-yard dash, vertical jump height, and length of the standing long jump. After a pretest on the three dependent variables, a 10 week weight program (parallel squat) and plyometric program (depth jumping) was implemented. A post test was administered on the three dependent variables and gain scores were recorded. One group of subjects trained with weights while the other group trained with the plyometric drills. A third group was added as a control group which did not train with either method but was pre and post tested in order to compare the results to the experimental groups. A comparison of improvements on the dependent variables (speed, vertical leap, and standing long jump) was analyzed between all groups. Any significant improvements were concluded to occur due to the implementation of the independent variables.

Hypotheses

The following hypotheses stem from the purpose of the investigation:

1) Weight training will not significantly improve speed in the 30-yard dash, vertical leap, or standing broad jump from the pretest to the post test.
2) Plyometric training will not significantly improve speed in the 30-yard dash, vertical leap, or standing broad jump from the pretest to the post test.
3) The control group will show no significant

improvement in the 30-yard dash, vertical leap, or standing broad jump from the pretest to the post test.

4) There will be no significant improvement differences between the weight lifting and the plyometric group in the 30-yard dash, vertical leap, or standing broad jump.

5) There will be no significant improvement differences between the weight lifting group and the control group in the 30-yard dash, vertical leap, or standing broad jump.

6) There will be no significant improvement differences between the plyometric group and the control group in the 30-yard dash, vertical leap, or standing broad jump.

Limitations

1) The amount of sleep or rest was not prescribed.
2) Diet and nutrition was not controlled.

Delimitations

1) The study consisted of 16 males and 13 females between the ages of 15-18 who did not participate on any athletic team.
2) Training sessions lasted 40-50 minutes, two days per week for 10 weeks.
3) The subjects did not participate in any other additional athletic training other than prescribed

in this study.

4) The control group did not participate in any athletic training during the ten week study.

5) The experimental groups did not miss more than twenty percent of the training sessions.

Assumptions

1) Maximum effort was exerted during the pre-test and post test.

2) Maximum effort was exerted with each repetition during training.

3) Equal gain scores between two individuals will show equal improvement even though they may have different starting and ending values.

4) The same attire will be worn during the pre-test and post test such as the same shoes and gym shorts.

5) Proper stretching that occured before each workout did not enhance performance.

6) Any significant improvements are due to the implementation of the training program.

Definition of Terms

Antagonist - a muscle that opposes the action of another muscle

Concentric contraction - muscle contraction while shortening

Eccentric contraction - muscle contraction while lengthening

Electromyography - electrical activity produced within a skeletal muscle

Extensor - muscle that increases the angle of a joint

Fast Twitch fiber - glycolytic; anaerboc; produces faster, stronger muscle contraction; low endurance

Flexor - muscle that decreases the angle of a joint

Hypertrophy - increased muscle fiber size

Inertia - the tendency of an object to remain in motion in the same direction unless acted upon by an opposing force

Isotonic exercise - movement against constant resistance, as in lifting a weight

Motor unit - a motor neuron and the muscle fibers activated by it

Muscle fiber - parallel muscle cell; largest independent contracting unit

Neuro-musclular - referring to the connection between nervous system and muscular system

Power - force times distance divided by time. A combination of strength and speed.

Protein Synthesis - producing a protein

Repetition - sequence of movement from beginning to end

Resistance training - forms of exercise involving the use of heavy loads with the primary goal to increase muscle strength, hypertrophy or both

Slow Twitch fiber - oxidative; responds to stimuli slower and with less force; high endurance

Strength training - muscle or muscle group lifting heavy loads for a relatively low number of repetitions resulting in increased muscle mass because of muscle hypertrophy

Synergist - a muscle that assists movement

Ventricle - bottom half of the heart that sends blow flow to the lungs and to the body

Work - force times distance

CHAPTER II

REVIEW OF LITERATURE

The literature reviewed will include the following topics: strength training, plyometric training, speed development, vertical jump, standing long jump, and similar experimental studies. Strength training will discuss muscle adaptations, training principles and the parallel squat. Plyometric concepts and the depth jump will be the focus of plyometric training. The final topic of discussion will involve studies similar to the experimental design used in this study.

Weight training has been proven to increase strength and has been an accepted concept for many years in this country[4, 5, 25, 29]. It has also been the belief for many years that weight training decreases speed, agility, flexibility and explosive movement. This concept, although diminishing in recent years, is still accepted by coaches and physical educators today. The standing long jump and vertical jump have often been used in studies as measures of power, and along with speed, was the focus of improvement in this study.

Plyometrics is a relatively new training method which migrated into this country in the mid "70's" from European coaches and researchers. The ultimate purpose of plyometrics is to develop explosive leg power and not necessarily leg strength[1, 2]. It is a speed-strength training method aimed at improving the neuro-muscular system's reactive ability to quickly switch from an eccentric to a concentric contraction[22]. Several studies have focused on the effects of plyometrics on the vertical leap and the standing long jump but relatively few studies have also incorporated speed as a dependent variable.

Strength Training

Muscle Adaptations and Training Principles

Strength exercises in all sports events are important means of specialized physical preparation which ensure the functional base for mastery of effective technique[26]. This statement indicates that the athlete should possess a foundation of strength not only for sheer strength but also for the coordination and synchronized movements of motor skill. This phenomenon is better understood after knowing about the muscle adaptations which occur due to a strength training program.

The increased ability of a muscle to generate force following resistance training results from the adaptation of the muscle fiber and the extent to which the motor unit can activate the muscle (neural adaptation)[4]. Strength training is an an anaerobic exercise which is an activity using muscle groups at high intensities that exceed the body's capacity to use oxygen to supply energy[27]. The type of fiber capable of functioning under this intensity is the fast twitch fiber.

Therefore, strength training involves selectively training this fiber instead of the slow twitch fiber which functions mainly during endurance activities[4]. After hard exercise, significant muscle cell damage occurs[21]. The muscle must recover. During recovery, muscle protein synthesis increases, augmenting incorporation of amino acids into muscle protein causing muscle hypertrophy[41] (increase size). This occurs as a protective device to prevent similar destruction to the muscle fiber if a similar overload is placed on the muscle. This hypertrophy is due to an increase in the following: the size of the myofibrils per muscle cell, total protein (especially actin and myosin which is the smallest contracting units of a muscle fiber) capillary density, and amounts and strength of connective, tendinous, and ligamentous tissue[27]. Many studies have shown that weight training programs will also increase lean body mass and decrease the percentage of body fat[17]. The heart also adapts to stresses placed on it from a rise in blood pressure during weight training by increasing the thickness of the left ventricle wall without an increase in volume[27].

Neural adaptations have also been reported to occur due to strength training. Changes in the nervous system resulting from strength training include increased recruitment of motor units, increased reflex potentiation and improved synchronization[4]. Reflex potentiation is the ability of motor units to fully activate during maximal contraction enhanced by the ability of the subject to recruit additional motor units or discharge the motor units at a faster rate[4]. Regular weight training synchronizes the motor units so they are activated at the same time which increases the strength of a contraction in conjunction with a hypertrophied muscle.[4]

Training Principles

The adaptability of the muscle fiber to prevent cell damage from a weight training overload decreases the progression of strength gains; therefore, a progressive weight training program will be implemented in this study. The three weight training principles followed in this study include:[27]

1) Overload principle - This states that strength and size of a muscle will increase only when the muscle performs for a given period of time against workloads that are above those normally encountered.
2) Progressive resistance principle - The resistance (pounds of weight) against which the muscle works should be increased periodically as gains in strength are made.
3) Principle of specificity - Weight-resistance training appears to be motor skill specific. Thus, weight training programs should exercise the muscle groups actually used in the sport or

activity the person is training for and should simulate as closely as possible the movement in that activity.

The specific weight program will be described during the methods and procedures.

Parallel Squat

The parallel squat will be performed with free weights. This means the lifter must control the weight without the aid of a machine. For maximum benefits, the squat must be performed with proper technique for the full range of motion. A parallel position is achieved when the mid line of the thigh is parallel to the lifting surface. Done correctly, the squat will strengthen the powerful and explosive quadraceps, groin, and hips extensors. This lift will also enhance the density of the bones, and increase the thickness and tensile strength of the ligaments and tendons[29]. Figure 3 (page 17) highlights the muscles involved in the parallel squat.

The suggested number of sets and repetitions for desired strength gains for this study was adopted from current research. Pate and associates[28] report that optimal rates of strength gains occur when the established resistance allows no more than 5 to 7 repetitions of a movement and when three sets of the exercise are performed in a training session. Nieman[27] reports the best weight lifting system for increasing strength is three sets of 6-8 repetitions. Since the subjects in this study have never

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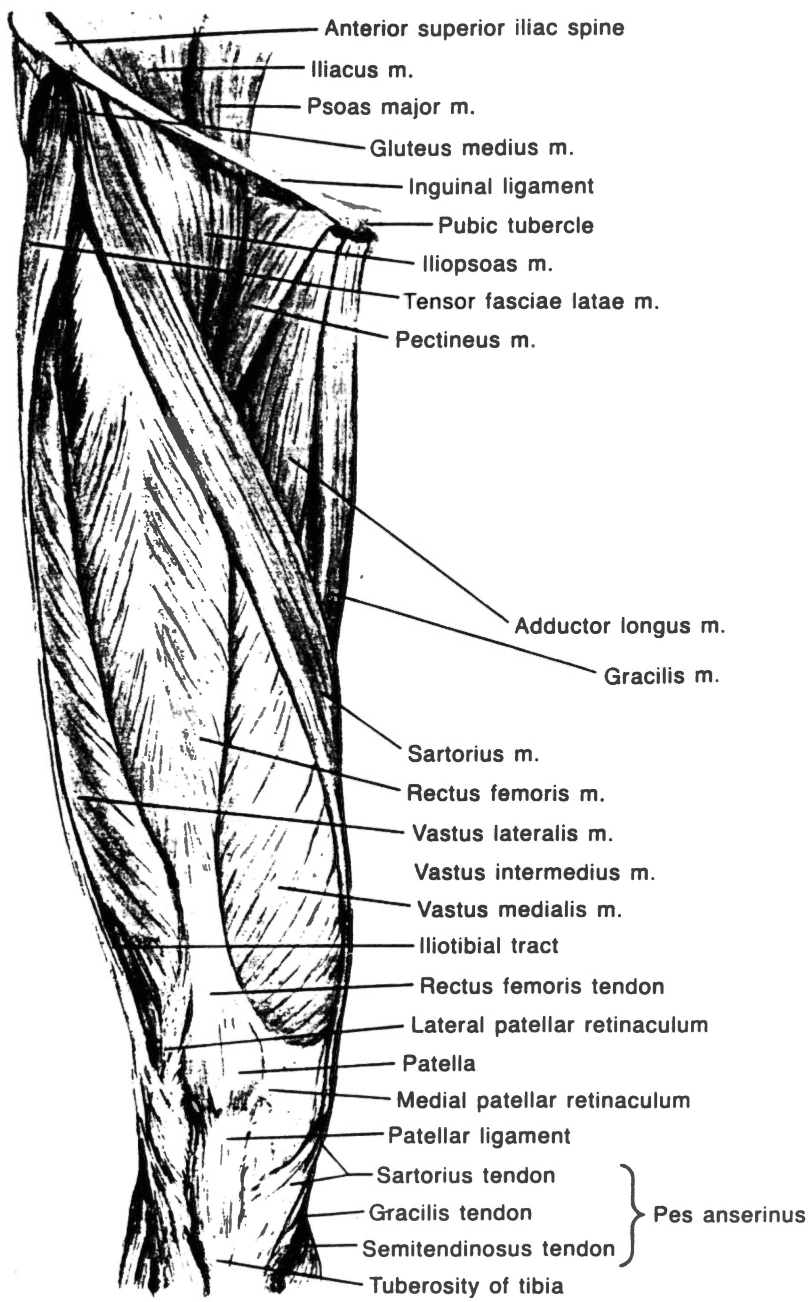


Figure 3. Muscles of Front of Hips and Thighs

participated in a weight training program, a modified program with higher repetitions will be used to ensure proper technique before progressing to lower repetitions with maximum resistance.

Plyometric Concepts

A body movement that requires a high final velocity such as jumping and throwing can best be achieved by starting it with a movement in the opposite direction. For example, when throwing a baseball, a movement in the opposite direction is needed to develop positive acceleration for the original intended movement. Another example involves stretching a rubber band farther before letting it snap back to its natural state producing more potential force. These examples are similar principles utilized during a plyometric exercise. As stated earlier, plyometrics attempt to bridge the gap between speed and strength. This bridge is accomplished by training the "stretch" or "myotatic" reflex which exists in all muscles[13]. The myotatic reflex elicits contractions of homonymous muscles (same muscle that was stretched) and synergist muscles while inhibiting antagonist muscles[17]. With plyometrics a muscle must first be stretched. A concentric muscle contraction immediately following an eccentric contraction is much stronger than a concentric contraction not preceded by prior stretching[38]. When a muscle resists overstretching, the stretch receptors cause proprioceptive nerve impulses to travel to the spinal cord and return to the same muscle.

The result of this process is a powerful muscle contraction to prevent overstretching.[32] These proprioceptors are called muscle spindles and golgi tendon organs which detect muscle tension, static length, velocity of stretch, and pressure[12]. This gathering phase of the muscle stretch is called the amortization phase and is described as the time the athlete makes first contact with the surface until just prior to reversal of the movement[13]. This is the eccentric contraction. The time spent on the ground is training the neuro-muscular reactive ability of the athlete. The athlete should treat the time spent on the ground as a hot bed of coals for the purpose of decreasing this time frame. The shorter the support time (time spent on the ground before rebounding) the greater the athlete's neuro-muscular reaction to the ground contact stimulus[11]. The faster a muscle is forced to lengthen, the greater the tension it exerts.[39]

So what causes this more powerful concentric contraction following a pre-stretched muscle. Two studies[3, 10] revealed that this powerful contraction is accounted for by the muscle's ability to store elastic energy during the amortization phase. The results concluded that all muscles have this ability to absorb and temporarily store mechanical energy in the form of elastic energy for later re-use. This is why depth jumping has proven to be one of the best methods of plyometrics. Depth jumps increase the potential energy stored by using the force of gravity and the weight of the body to increase the rate of stretch occurring during the eccentric phase. Bobbert, Huijing, and Schenau[8] showed that depth jumps achieved higher power output valves of the knee extensors and plantar flexors than any other jump technique.

Depth Jumps

A depth jump is executed by stepping off an elevated platform and, upon landing, immediately rebounding with maximum effort. In this study one repetition will include two depth jumps demonstrated in Figure 2 (page 6). The muscles trained during the depth jumps are primarily the hip and knee extensors similar to the muscles used in the parallel squat displayed in Figure 3 (page 17).

The next question that needs to be answered is what dropping height should be incorporated for optimum improvement of jumping height? The review of literature shows varying results. Veroshanski[36] recommends subjects to drop from a height of .7 to 1.1 meters. Adel[1] showed that dropping height between .3 and .5 meters is equally effective as dropping height between .7 to 1.1 meters for improving vertical jump height. Komi and Bosco[16] concluded that the stretch load (drop height) between .2 to .6 meters revealed vertical jump improvement for males and a stretch load between .2 to .5 meters is the best height for females. Asmussen and Peterson[3] found that energy output increased (measured by jump height and body weight) up to a dropping height of .4 meters. Similar results were reported by Bobbert Huijing and Schenau.[9] The rate of stretch was reported to be more important than the magnitude of stretch according to Wilt.[39] This study used a dropping height of .4 to .68 meters for the females and .68 to 1.1 meters for the males.

Speed

Is there an association between weight training or plyometrics and the improvement in running speed? Lezchenko[23] reported one of the most important roles played in training world class sprinters is specialized strength preparation. Sprinting occurs during three phases: driving, recovery, and planting. The driving phase takes place when the leg is pushing against the running surface to propel the body up and forward. Recovery occurs as the heel of the foot comes in close contact with the buttocks and swings forward to take another step. The planting phase begins as the foot strikes the ground causing a short eccentric contraction prior to the driving phase. Stamper[33] states that leg strength is the primary means of improving stride length. Stronger legs enable the sprinter to apply more force to the ground (driving phase), thus propelling the body farther forward with each step. Pushing back against the running surface and more rapid leg movement are both paramount to success in sprinting. Leg frequency must be closely associated with force developed against the ground.[13] Improving leg strength seems to be beneficial for improving the driving phase of sprinting.

The principle underlying plyometric training is closely associated with the planting phase of sprinting. Plyometrics train the neuro-muscular system by decreasing the amortization time which is the time of first contact with the landing surface until reversal of the movement. The amortization phase is similar to the planting phase of sprinting. A short support time on the ground (the transition between planting and driving) is reported to be a priority to sprinters[11].

Vertical Jump and Standing Long Jump

Matveeve and Levchenko[22] found that as jumping height increased, three things happened: 1) the duration of the interaction of the support surface (amortization phase) decreased; 2) force of the take off increased; 3) force impulse in both the vertical and horizontal planes increased. These researchers also state that scientific research underscores the importance of a jump in possessing a high level of yielding (eccentric-concentric) strength in his support leg muscles.[22] These results show that strength is not only needed to increase the force of take off but also to reverse the body's inertia during the landing (eccentric) phase of a jump.

From the literature reviewed, the strength development of the hip and knee extensors is needed to improve vertical jump height. Bangerter[5] concluded that gains in vertical jump were registered by experimental groups which strengthened knee and/or hip extensors. The control group (no strength training) and the plantar flexor strengthening group did not register significant jump improvement.

Taranov[34] compared the strength gains of the knee extensors relative to the strength gains of the plantar flexors and its effect on vertical jump height. He found subjects who increased the knee extensor muscles at a higher rate compared to the rate of increase of the plantar flexor muscles showed more improvement in the vertical jump. The hip and knee extensor muscles will be the focus of training in this study.

Experimental Studies

Plyometrics and weight training have been the focus of several studies, with varying experimental designs, to show improvements on one or more of the dependent variables used in this study.

Weight training has been used as an independent variable to show its effect on vertical leaping ability. Taranov[34] and Bangerter[5] showed that improving knee and hip extensor strength through weight training correlated with increased vertical leap scores. McClements[25] conducted a similar study but added a strength exercise for the hip flexors and concluded that all muscle groups (leg extensors and hip flexors) contribute to gains in vertical jump height. One study that used weight training did not show a significant increase in vertical jump when comparing the experimental group to the control group.[24] A motor learning explanation was stated as a possible reason for the non-significant results since the control group was composed of basketball players and the study occurred during in-season training. Only one experimental study[40] that used weight training incorporated speed and jumping ability as the dependent variables. One group trained with weights (non-explosive movement) while the other group also trained with weights but used explosive movements. Both programs equally increased speed but the explosive movement group showed significantly more improvement on both types of jumps.

Several studies using plyometrics have also revealed improvement on vertical jump height.[1, 3, 6] Scoles[32] revealed similar results, but added the standing long jump along with the vertical leap, and showed significant improvements with both types of jumps. Al-Ahmad[2] also showed significant improvement on the standing long jump and vertical leap but the plyometric group did not improve significantly on speed in the 40-yard dash.

Other experiments have compared the effects of both training programs, using plyometrics and weight training in the same study with one or more of the dependent variables used in this study. Two studies[7, 30] revealed improved vertical jump height with the weight training and plyometric group compared to the control group but showed no significant difference between the experimental groups.

A variation to the previous experiments was the addition of an experimental group who trained with weights and plyometrics in the same training session. Kitpet[19] compared a plyometric and weight training group to a weight training only group and found improved vertical jump height results within both groups but showed no significant differences between the groups. A similar study by Clutch, Witton, McGown, and Bryce[14] revealed significant improvement on the vertical jump by the combined weight training and plyometric group but the weight training group did not improve significantly at the ($P<.05$) level. This group trained only for six weeks performing half squats which do not produce maximum strength gains in the hip extensor muscles.

Only one study reviewed contained all the independent and dependent variables used in this study. Gemar[15] compared the effects of a weight training group and a plyometric group on speed in the forty meter dash, standing long jump and vertical jump ability. Both groups improved significantly ($P<.05$) on all variables compared to the control group but showed no difference between the two training programs. Gemar allowed the weight group an extra day per week to train. A difference in this study was that the frequency of training sessions per week was the same for both experimental groups.

Several studies, using weight training and/or plyometrics, have included the vertical leap as the dependent variable, but relatively few studies have observed the effects of these training programs on speed and/or standing broad jump.

CHAPTER III

METHODS AND PROCEDURES

Research Design

The subjects in this study were high school students who enrolled in the class voluntarily knowing beforehand that they would participate in the study. These are students who did not participate on a high school athletic team sport or any other type of athletic training associated with improving athletic abilities. The students were separated into two experimental groups by randomly selecting the names out of a hat and replacing the name back into the hat after each selection. A control group consisted of volunteers from high school students who also did not participate in athletic training.

One class period was devoted to demonstration of proper technique and practice time in the vertical leap, standing long jump and 30-yard dash. A pretest was administered for all groups by testing each variable on separate days. The control group was told not to participate in any athletic training during the time of the study.

Five class periods were devoted to demonstration of proper technique and practice of weightlifting, plyometrics, and spotting. During the fifth class period, the students demonstrated proper technique which determined starting workout weights and jumping heights. The experimental groups trained two days a week for ten weeks during the class period. A ten minute warm-up and stretching routine preceded each session with five minutes reserved after the workout for stretching. After the ten week training session was completed, a post test was administered to all groups under the same conditions as the pretest.

Weight Training

The weight training group performed the parallel squat with free weights. Proper technique is shown in Figure 1 (page 4). Starting workout weight was determined by allowing the student to perform the maximum amount of weight for ten repetitions while using proper technique. Improper technique consisted of not reaching the parallel plane or leaning forward during the extension of the hips, transferring the resistance to the back muscles. Safety braces, which prevented the lifter from falling below parallel, were placed under the lifter for protection.

During the first three weeks, the lifting group performed 3 sets of 10 repetitions per session. Three to five minutes were allowed between repetitions. If he or she successfully performed all of the repetitions using proper technique, the workout weight was increased for the next session. A record was kept for each individual to show how much weight should be used for each workout. This record (Table I, page 42) will also show the progression of strength gains that occurred during the ten week period.

During weeks 4-6, the workout was changed to 4 sets of 8 repetitions per session. During last four weeks, the lifting group completed 5 sets of 6 repetitions per session.

This program follows the three principles of weight training stated in the review of literature.

Plyometrics

The depth jump was the plyometric technique executed by the other experimental group. One depth jump was performed by stepping off an elevated platform and, upon landing, immediately jumping onto another elevated platform. Starting jumping height was determined by successfully completing 10 depth jumps onto the highest platform. A successful depth jump was determined if the subject's feet landed completely on top of the platform without losing his or her balance. Two spotters stood on each side of the subject for protection if the subject fell. The workout program consisted of 30 repetitions, two days per week for ten weeks. Between forty-five seconds to a minute were allowed between each repetition. One repetition included two depth jumps. For this reason, two boxes at each jumping height were needed. Figure 2 (page 6) shows proper technique and the completion of one repetition. In order to complete one repetition, the dropping height started on the elevated platform one level below the jumping height. After one depth jump was completed, the subject completed the repetition by executing another depth jump using a dropping height equal to his/her jumping height. The elevated platforms ranged in heights between .3 and 1.1 meters. If the subject successfully completed all 30 repetitions, jumping height was increased for the next session. A jumping height progression chart in Table II (page 43) shows the levels achieved for the ten week period.

Testing Procedures

Vertical Jump

The vertical jump was measured by the Sargents Vertical Jump Test. Chalk was placed on the subjects preferred hand and was told to stand erect with the chalked hand next to the wall which had a measuring tape stuck to it. A base measurement was taken with the arms and fingers fully extended while the subject's feet were flat on the ground. The subjects were instructed to jump and reach as high as possible and touch the wall at the highest point of the jump. Since prior instruction and practice time were given for the vertical jump technique, no further instructions were needed. The difference between the highest point touched and the base measurement was the height of the jump. Three trials were allowed for each subject. If the subject increased on all three trials, a fourth trial was allowed. The highest jump for each subject was recorded.

Standing Long Jump

Measuring tape was placed on the gym floor along the out of bounds line. Chalk was placed on the heels of subject's feet. The subjects were instructed to place their toes on the starting line six inches to the side of the measuring tape. They were told to jump as far as possible. Prior instruction and practice time were given for technique. The length of the jump was measured from the starting line to the closest heel mark. If any part of the body touched the floor behind this mark, that point was determined as the length of the jump. Three trials were allowed for each subject. If the subject increased on all of the trials, a fourth trial was allowed, and the farthest jump was recorded.

Thirty-Yard Dash

Speed measurements were taken in the gym to ensure that the weather conditions did not play a role in the results. From a standing start with their toe on the starting line, the subject's were instructed to sprint as fast as possible five yards past the finishing line. The stop watch was started on the subjects first movement and stopped when the anterior portion of the body crossed the 30-yard mark. Three trials were allowed for each subject. If the subject increased on all of the trials, a fourth measurement was allowed. The fastest time was recorded.

Statistical Analysis

Two-way analysis of variance (ANOVA) with Repeated Measures was the procedure used to determine if there were any significant differences among the three groups in pre to post test scores. The Newman-Keuls (Post Hoc) range test procedure determined where the differences were located among the means. All statistical tests were performed at the .05 level of significance.

Each hypothesis was tested in the following manner:

1) The first hypothesis was tested by a two-way ANOVA comparing pre and post test means for speed in 30-yard dash, vertical jump, and standing long jump within the parallel squat group.
2) The second hypothesis was tested by a two-way ANOVA comparing pre and post test means for speed in the 30-yard dash, vertical jump, and standing long jump within the depth jump group.
3) The third hypothesis was tested by a two-way ANOVA comparing pre and post test means for speed in the 30-yard dash, vertical jump, and standing long jump within the control group.
4) The fourth hypothesis was tested by a two-way ANOVA comparing the change in the means for speed in the 30-yard dash, vertical jump and standing long jump between the parallel squat group and the depth jump group.
5) The fifth hypothesis was tested by a two-way ANOVA comparing the change in the means for speed in the 30-yard dash, vertical jump and standing long jump between the parallel squat group and the control group.
6) The sixth hypothesis was tested by a two-way ANOVA comparing the change in the means for speed in the 30-yard dash, vertical jump, and standing long jump

between the depth jump group and the control group.

CHAPTER IV

RESULTS AND DISCUSSION

It was the purpose of this study to determine if significant improvement could be obtained in the vertical jump, standing long jump, and speed in the 30-yard dash due to the treatment of weight training and plyometrics. The independent variables were the parallel squat and depth jumps. A comparison between these two experimental groups and a control group was made to determine if there were significant differences between the groups. Significant improvement was determined at the .05 level of significance.

Analysis of variance procedures indicated there were significant differences between the groups from pre to post test evaluations. A Newman-Keuls post hoc procedure revealed significant improvements in the parallel squat and depth jump groups. No significant differences in improvements were determined from pre to post tests when comparing the parallel squat groups to the depth jump group.

The plyometric group significantly improved on speed in the 30-yard dash, vertical jump and standing long jump. Although significant differences were not found between the two training programs, the plyometric group showed considerably more improvement in the standing long jump compared to improvements made by the weight training group.

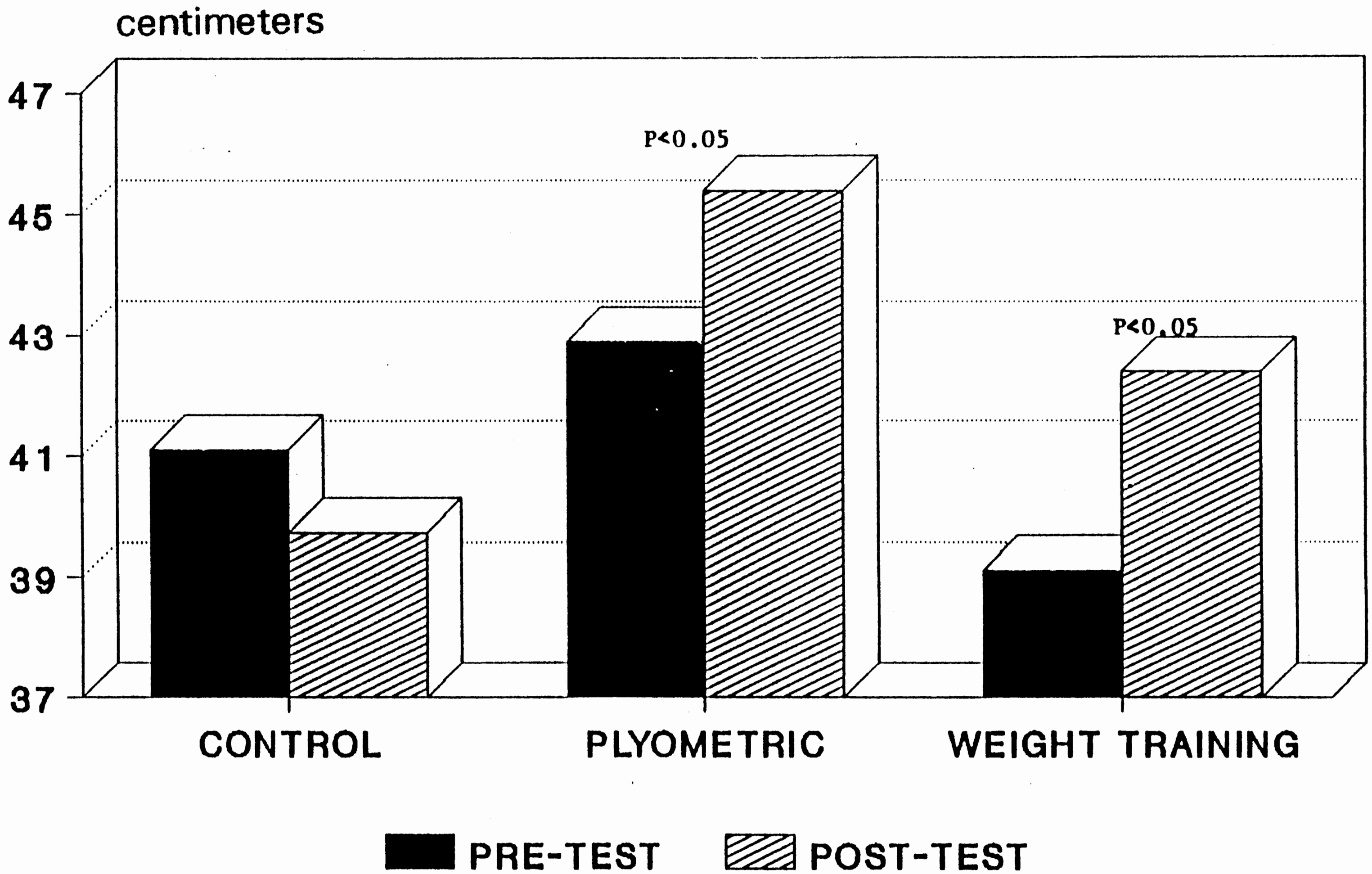
The parallel squat group improved significantly in the vertical jump and speed in the 30-yard dash compared to the control group. Considerable improvement was also determined in the standing long jump revealing significant improvement if .06 was the level of significance. Table III (page 44) reveals the ANOVA results.

Presentation of Data

Figure 4 (page 35) reveals vertical jump mean scores from the pre to post tests for each group. The control group did not improve but actually showed a mean decrease of 1.3 centimeters (cm). The plyometric group improved 2.51 cm and the weight training group improved 3.25 cm. Standard deviations for the vertical jump will be listed by pretest first, followed by the post test. The control group standard deviations were 10.2 cm and 9.8 cm. Plyometric standard deviations were 10 cm and 9.1 cm while the weight training standard deviations were 12.7 cm and 12.3 cm respectively.

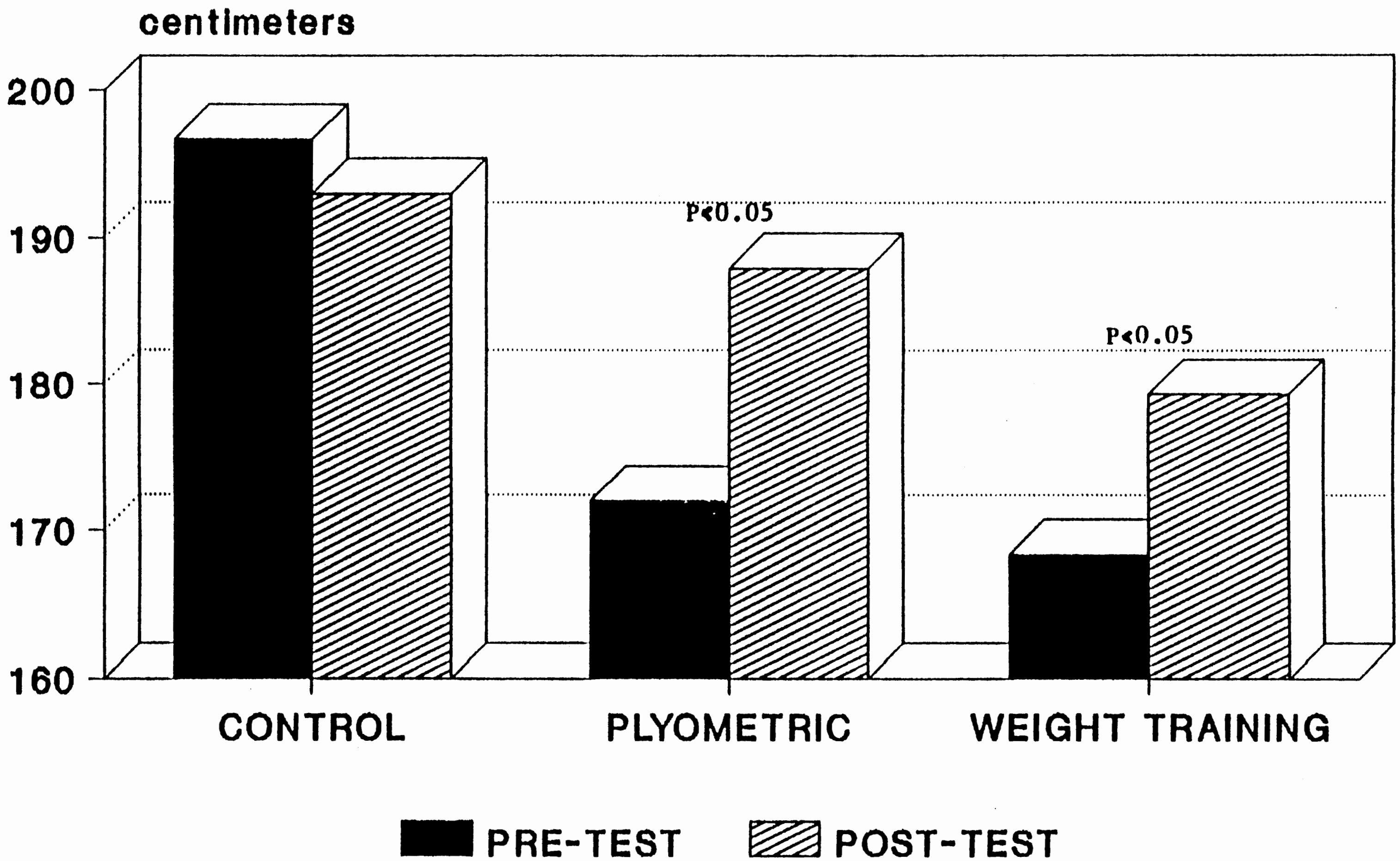
Figure 5 (page 36) reveals standing long jump means from pre to post tests. The control group decreased with a mean of 3.7 cm while the plyometric group improved 16 cm and 10.7 cm for the weight training group. Standard deviations listed from pre to post tests are as follows: control 43.8 cm and 33.1 cm, plyometric 34.5 cm and 32.3 cm, weight training 25.7 and 24.3.

Figure 6 (page 37) reveals 30-yard dash means from pre to post tests. The control group decreased in speed 0.01



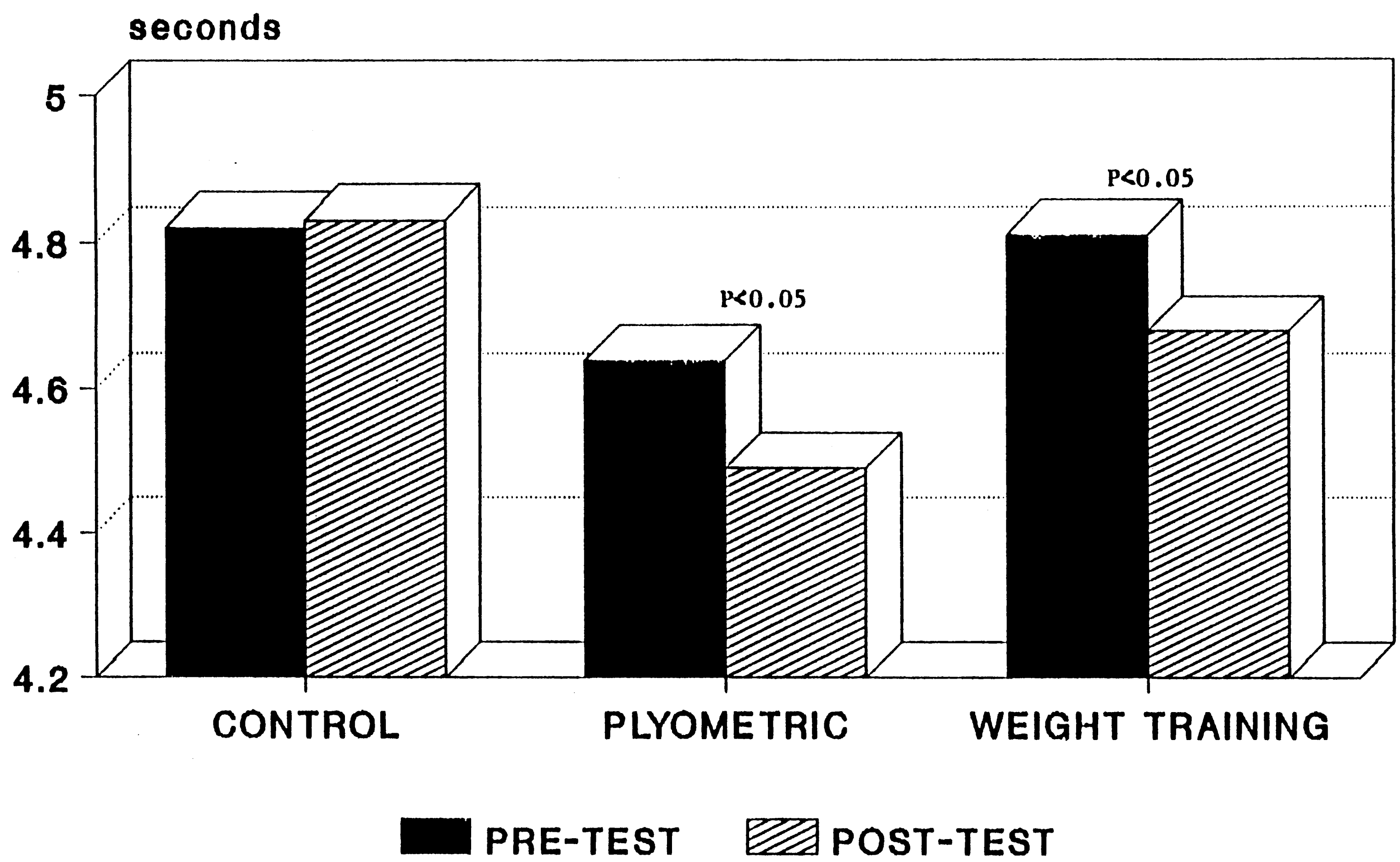
* P<0.05

Figure 4. Pre- to post-test means for vertical jump by groups.



* P<0.05

Figure 5. Pre- to post-test means for long jump by groups.



* P<0.05

Figure 6. Pre- to post-test means for 27.43 meter (30 yds.) dash by groups.

seconds (sec) while the plyometric group and weight training group increased in speed 0.16 sec and 0.13 sec respectively. Standard deviations listed from pre to post test are as follows: control 0.48 sec and 0.51 sec, plyometric 0.39 sec and 0.36 sec, weight training 0.34 sec and 0.33 sec.

Hypotheses

The following hypotheses were tested at the .05 level of significance.

1) Rejected in that the parallel squat group showed significant improvement from pre to post test evaluations in the vertical jump and speed in the 30 yard dash. It was accepted for the standing long jump.
2) Rejected in that the depth jump group showed significant improvement from pre to post test evaluations.
3) Accepted in that the control group did not significantly improve from pre to post test evaluations.
4) Accepted due to no significant improvement differences between the parallel squat and depth jump group.
5) Rejected for the vertical jump and speed in the 30 yard dash but accepted for standing long jump when comparing the parallel squat to the control group.
6) Rejected in that the depth jump group showed significant improvement differences when compared to the control group.

Discussion

The results of this study indicate that both training programs are effective methods for improving power as measured by the vertical jump, standing long jump, and speed in the 30-yard dash. All members of the weight training group improved knee and hip extensor strength due to the treatment of the parallel squat. Assuming all other factors which could improve scores on the dependent variables were controlled, the improvements demonstrated were due to the strength gains from weight training. All members of the plyometric group improved depth jumping heights implying the improvement of the neuromuscular reactive ability. This bridges the gap between speed and strength referred to as power.[12, 13, 37]

The three dependent variables have been regarded as assets which most skilled athletes possess. From the results of this study, weight training and plyometrics improve these dependent variables. If coaches and physical educators wish to improve these qualities of their students, these training methods should be implemented into their training programs.

CHAPTER V

SUMMARY, FINDINGS, CONCLUSIONS RECOMMENDATIONS

This study compared the effects of the parallel squat and depth jumps on speed in the 30 yard dash, vertical jump, and standing long jump. A pre and post test was administered on these three dependent variables in order to compare improvement differences among the two experimental groups and a control group. The two experimental groups trained two days a week for ten weeks while the control group did not participate in any athletic training. Statistical analysis revealed significant improvements by both training groups on all dependent variables but revealed no significant improvement differences between the training groups. The data was analyzed at the .05 level of significance.

Findings

As stated earlier, both training groups showed significant improvement on the dependent variables from pre to post test scores. The control group did not improve from the pre to post test, but actually demonstrated slightly decreased performances on all dependent variables. The depth jump group improved significantly ($P<.05$) on all dependent variables while the parallel squat group improved significantly ($P<.05$) on the vertical jump and speed in the 30-yard dash. The parallel squat group also improved means on the standing long jump but only slightly missed the .05 level of significance.

Conclusion

The results indicate that both training methods are effective programs for improving speed and jumping ability. Weight training improves strength while plyometrics improve the neuromuscular reactive ability which are both components needed to improve power.

Recommendations

1) Podolsky and associates[31] concluded that strength of shoulder abduction significantly correlated with height of figure skating jumps. Further investigations could add an experimental group who would train the shoulder abductors only or a combination of lower and upper body training.
2) Further studies may consider extending training longer than ten weeks to observe further improvements and adding more subjects to each group.
3) Further investigations may also consider an experimental group combining weight training and plyometrics within the same group.

TABLE I

STRENGTH PROGRESSION CHART
NUMBER OF WEEK

Student #	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
One	115	125/145	145/145	150/165	170/185	205/215	225/235	235/240	240/245	250
Two	55	65/75	80/80	80/80	85/90	95/100	100/100	105/110	110/110	115
Three	135	145/145	145/155	160/160	165/175	195/200	215/225	230/235	235/240	245
Four	115	125/125	125/130	130/135	140/145	145/150	155/155	155/170	175/180	190
Five	75	85/105	110/110	115/120	125/125	130/130	135/140	140/155	165/165	170
Six	55	65/75	80/80	85/85	85/85	90/95	95/110	115/120	120/120	125
Seven	55	65/75	80/80	85/85	85/95	100/105	115/115	120/125	125/130	135
Eight	55	55/65	65/65	75/75	75/75	85/90	100/105	115/120	125/125	125
Nine	55	65/75	80/80	85/85	85/85	95/100	100/100	105/110	110/110	115
Ten	175	185/195	195/195	205/210	210/210	210/215	225/235	235/240	245/245	250

TABLE II

PLYOMETRIC PROGRESSION CHART

	(height of jump in centimeters)					
	40	54	68	82	96	110
Student #						
Eleven			X	X	X	
Twelve				X	X	X
Thirteen			X	X	X	
Fourteen				X	X	X
Fifteen			X	X		
Sixteen		X	X			
Seventeen	X	X	X			
Eighteen		X	X			
Nineteen	X	X	X			
Twenty			X	X	X	

TABLE III

ANALYSIS OF VARIANCE

Vertical Leap Pretest and Posttest

Source	Sum of Squares	Degrees of Freedom	Mean Square	F	Tail Probability
Mean	101063.41062	1	101063.41062	438.44	0.0000
Group	170.08167	2	85.04083	0.77	0.6950
Error	5993.18851	26	230.50725		
Vertical	32.44826	1	32.44826	12.04	0.0018
VG	54.73219	2	27.36610	10.15	0.0006
Error	70.09694	26	2.69604		

Alpha = .05

Long Jump Pretest and Posttest

Source	Sum of Squares	Degrees of Freedom	Mean Square	F	Tail Probability
Mean	1935170.73702	1	19355170.7370	947.56	0.0000
Group	4280.27275	2	2140.13638	1.05	0.3650
Error	53098.85579	26	2042.26368		
Vertical	847.22402	1	847.22402	9.23	0.0054
VG	970.82104	2	485.41052	5.29	0.0118
Error	2385.92498	26	91.76635		

Alpha = .05

TABLE III (continued)

Speed in 30-Yard Dash Pretest and Posttest

Source	Sum of Squares	Degrees of Freedom	Mean Square	F	Tail Probability
Mean	1284.53810	1	1284.53810	4022.77	0.0000
Group	0.66421	2	0.33211	1.04	0.3677
Error	8.30223	26	0.31932		
Vertical	0.1262	1	0.1262	14.84	0.0007
VG	0.07131	2	0.03566	4.31	0.0241
Error	0.21485	26	0.00826		

Alpha = .05

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