STRENGTH AND FLEXIBILITY GAINS IN SUPPLEMENTARY WEIGHT TRAINING PROGRAMS USING TWO DIFFERENT WEIGHT TRAINING APPARATUS

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Weight Training is a method of improving muscular strength, endurance, and flexibility using any one of a variety of weight training apparatus. Physiologists agree that the best way to develop strength is by a combination of isotonic and isometric muscular contraction while others agree that isokinetic muscular contraction is best. The question consistently arises as to which weight training program is the best to use in developing gains of strength and flexibility.

The purpose of this study was to investigate strength and flexibility development as each is affected by three training programs using two apparatus: the Exer-Genie and the Super-Mini-Gym.

Thirty subjects were matched into three groups using McCloy's Age-Height-Weight Classification Index. All subjects participated in track and field while under going the six week supplementary weight training programs. Group I used the Super-Mini-Gym apparatus and Group II used the Exer-Genie device on Mondays, Wednesdays, and Fridays performing the leg press, curls, and the bench press. Group III served as the control group. The beginning number of sets and repetitions

were the same for both groups starting with three sets of two repetitions the first and second weeks and ending with three sets of four repetitions during the fifth and final weeks. The pretest and posttest consisted of testing for a Strength Index using leg strength, right grip strength, dip strength, and chin strength measures. Flexibility measures were taken for each subject consisting of right and left hip, knee, shoulder, and elbow joints.

Statistical treatment of the data was accomplished by analysis of covariance. The .05 level of confidence was selected as the significant rejection level.

An analysis of the data warrants the drawing of the following conclusions. Grip strength can be increased to a significantly greater level by using the Exer-Genie supplementary weight training program with participation in track and field activities.

Dip strength can be increased to a significantly greater level by using the Exer-Genie supplementary weight training program with participation in track and field activities than by using the Super-Mini-Gym supplementary weight training program with participation in track and field activities.

Strength Index scores can be increased to a significantly greater level by using the Exer-Genie supplementary program with participation in track and field activities than by participation in track and field activities only.

Flexibility cannot be significantly differently affected by any one of the three programs undertaken in this study.

Three significant F ratios resulted from analysis of covariance of the strength measures but further group mean comparisons showed that no group was superior to the other two groups on a single measure. When comparing flexibility measures, none of the items showed significant F ratios. Therefore, no certain group in this investigation showed as being a superior training program with regard to changes in flexibility.

Based on the findings and conclusions of this study, the following recommendations are presented. The use of more than two weight training apparatus should be used to serve as an aid to coaches, physical educators, or individuals interested in acquiring an apparatus most helpful in developing components of physical fitness and strength. It would be of benefit to include more than one component of physical fitness to secure a total overview of physical fitness and strength developed by a weight training program. Periodic posttests should be administered to determine which group or groups retain the highest level of physical fitness and strength over varied periods of time after completion of the initial investigation.

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THESIS

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CHAPTER I

INTRODUCTION

Weight lifting is known to be of ancient origin and according to legend, Egyptian and Chinese athletes, nearly 5,000 years ago, demonstrated feats of strength. A Greek athlete of the 6th century B.C., Milo of Croton, performed a feat of strength during the era of the ancient Olympic Games, lifting an ox onto his shoulders and carrying it 200 yards, the full length of the stadium at Olympia (7). During the following centuries the sport continued to be practiced in many parts of the world. Weight training, a method of strength development, evolved from the sport of weight lifting.

It seems appropriate at the start to distinguish between weight training and weight lifting. Weight lifting is an international, competitive sport. Weight training is a method of improving muscular strength, endurance, and flexibility, using any one of a variety of weight training apparatus. A question consistently arises, which weight training apparatus is the best to use in developing strength?

Many different and unique devices used in weight training programs are on the market today. They sell from thirty dollars to as much as $4,000.00. This author believes that many of these apparatus do not achieve the purposes for which they were intended. A few were invented for the purpose of making money and not to reach the objectives of a weight training program.

According to Rasch (5), in past years three types of muscular contractions have been used in weight training programs. These are isotonic, isometric, and lengthening contractions. Isotonic contraction is when the muscle actually shortens and moves a load, such as a barbell, accomplishing a certain amount of work. These contractions are defined as concentric. Isometric contraction is when the muscle is unable to move the load, such as a fixed bar, and does not shorten and technically no work is accomplished. This is known as static contraction. The third type of muscle contraction is referred to as lengthening, which forces the contracted muscle to extend, as when a barbell is taken from supports and slowly lowered. This is also a form of isotonic contraction and is known as eccentric contraction in order to differentiate it from concentric movement.

Physiologists seem to agree that the best way to develop strength is by a combination of isotonic and isometric muscular contraction. There are a variety of weight training apparatus which employ one or a combination of the above defined muscular contractions. The barbells have been used since the beginning of a weight training program.

A new weight training device appeared on the market in 1964 that had been developed as a means of keeping our astronauts physically fit in the space program. This new device has a trade name of Exer-Genie (2). It uses a combination of isotonic and isometric muscular contractions.

Recently, Perrine, a Consultant Engineer, Department of Physical Therapy, Institute of Rehabilitation Medicine, New York, developed a clinical weight training apparatus called the Cybex (6). This machine provides an isokinetic type muscular contraction.

Perrine (4) is the originator of a new theory of muscular contraction known as isokinetic contraction. He defines an isokinetic contraction as one occurring against a load which allows movement at a mechanically fixed rate of speed and offers resistance proportional to the muscle's dynamic tension developing capacity at every point in its shortening range and at some optional shortening speed.

Today isotonic and isometric weight training methods are used to develop physical fitness. These methods are successful in building strength, but how do they affect other components of physical fitness? What differences exist between strength gains and gains in other physical fitness components as developed by different apparatus in weight training programs?

One of these components is flexibility, defined as the range of joint motion. Affecting factors in range of movement of muscle-joint flexibility are muscle extensibility, joint structure, and condition of ligaments and fascia surrounding the joint (3).

Statement of the Problem

Physical educators and others concerned with establishing a weight training program need to know which weight training programs and apparatus are most effective in developing strength and flexibility.

Purpose of the Study

It was the purpose of this study to investigate strength and flexibility development as they are affected by three different programs of training. The Super-Mini-Gym Program consisted of participation in track and field activities supplemented by a weight training routine using the Super-Mini-Gym. The Exer-Genie Program consisted of participation in track and field activities supplemented by a weight training routine using the Exer-Genie. The Control Group only participated in track and field activities. Answers to the following questions were sought:

1. Will the Super-Mini-Gym group develop significantly greater strength than the Exer-Genie group or the control group?

2. Will the Exer-Genie group develop significantly greater strength than the Super-Mini-Gym group or the control group?

3. Will the control group develop significantly greater strength than the Super-Mini-Gym or Exer-Genie groups?

4. Which of the three training programs causes a change in flexibility?

5. Under the conditions set aside by this investigation, which of the three programs is most desirable with regard to strength and flexibility changes?

Limitations of the Study

The limitations of this study are defined as follows:

1. Total cooperation of subjects to train maximally was expected.

2. All subjects were participating in junior high track and field athletics.

Delimitation of the Study

The study was limited to male seventh and eighth grade students enrolled at Newcastle Junior High School, Newcastle, Texas, during the 1970-71 school year.

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CHAPTER II

REVIEW OF LITERATURE

That muscular activity will increase muscular strength is a readily verifiable fact. Steinhaus (19) observed that in the last half century research has begun to discover the basic factors accounting for increased muscular strength. Morpurgo (19) found that there was no increase in the number of muscle fibers with increase in strength showing hypertrophy. Muller (19) was reportedly the first to experiment with isometric exercises and, after a decade of work, claimed that muscular strength would increase by a precise percentage if specific procedures were followed.

From these history-making experiments essential conclusions can be made. First, the extent of muscle hypertrophy is determined by the number of muscle fibers, by heredity, and by exercise, up to a fixed limit. Second, no matter how much a muscle is used, it will not grow larger or stronger until it is overloaded. Third, rapid training induces only a losely "anchored" adjustment of the muscle to the increased demands made on it. If, however, this increased strength is maintained for a time it becomes fixated in the muscle (19).

A search of literature reveals a number of studies that have investigated flexibility and many more that investigated the effects of programs of weight training, but reveals little related to the relationship between development of muscle strength and flexibility. Kraus and Raab (12) have reported in considerable detail the theoretical aspects of muscle strength and flexibility.

Wallis and Logan (21) imply that to develop flexibility an individual must increase effort regularly. They reflect that even though a person has developed his body in terms of strength tone, he may still not be flexible enough to move easily about. They refer to isometric exercise as a fast way to develop strength and isotonic exercise as a way to develop high level strength.

Cureton (7) conducted flexibility measurements on 1948 United States Olympic men swimming champions and found that flexibility measures were above average in all events. He believes swimmers are less strong per pound of body weight as compared to other athletes.

Morehouse and Rasch (16) believe training periods should be followed by special exercises to increase strength and flexibility. Their opinion was that sports activities fail to meet the need for reserve strength, endurance, and flexibility.

Davis and Logan (9) indicated most studies in flexibility have utilized isotonic exercises. Several studies have combined isotonic and isometric exercises and compared their affects on flexibility. Now with the introduction of isokinetic exercises, a question has arisen regarding the effect of this type of exercise on flexibility.

Lauback and McConville (15) investigated muscle strength, flexibility, and body size of adult males and found very little relationship between muscle strength and flexibility using isotonic and isometric exercises. Morehouse (17) and Cureton (8) have suggested that isotonic and isometric exercises, through restricted ranges of motion, will have a shortening effect on the working range of a muscle.

Gardner (11) studied the effect of isometric and limited range isotonic exercise on elbow and knee flexion. He found no evidence that either brief periods of maximal isometric exercise or isotonic exercise, using heavy resistance over a limited range of motion, had significant effect on the volitional flexibility of either the elbow or knee joints.

Research relating muscle strength and anthropometric dimensions has been reported by Clarke (4, 5) and indicated that body weight and the girth of the flexed-tensed upper arm correlated significantly with selected cable tension strength tests. Cureton (6) reported that the size of the arms and legs fail to indicate their strength.

Chui (3) compared the effects of isometric and dynamic weight training on flexibility and found that one method was not better than the other. Both methods resulted in gains in strength and speed. Capen (2) concluded in a study to determine efficiency of muscle action that weight training added to agility, speed, and power of movement. Kraus and Raab (14) reported that weight training caused satisfactory gains in development of strength and flexibility.

All of the published research in which isokinetic exercises are compared to conventional methods of strength development shows isokinetic exercises to be superior. In a study by Thistle (20) it was reported that after an eight-week period of exercise involving sixty subjects, the experimental group using isokinetic exercises showed an improvement of 35.4 percent in total ability, while the group using weight lifting methods improved only 27.5 percent, and the group using isometric contraction improved only 9.2 percent. The results in peak force ability showed the isokinetic group improving 47.2 percent, the weight lifting group 28.6 percent, and the isometric group 12.1 percent.

Moffroid (16) found that isokinetic exercise increased the work a muscle could do more rapidly than either isometric or isotonic exercise. It was also found that muscular response to different loading systems tends to be very specific, which means a muscle overloaded in a partial range of motion will increase significantly more in this range than in other, less exercised joint positions.

Alexander, Martin, and Metz (1) investigated the effects of a four-week training program on certain physical fitness components of conditioned male university students using the Exer-Genie. Results of the study indicated that for physically conditioned young males, changes in girth, and skinfold measurements, improvement in muscular strength and endurance, and a small positive improvement in cardiovascular fitness occurred.

Duncan (10) investigated the effects of volleyball, weight training, the Exer-Genie exercises, and combination volleyball-Exer-Genie programs on the development of physical fitness. He found the combination volleyball-Exer-Genie group improved stamina significantly better than any other. Hoffman (13) found that a combination isotonic-isometric exercise program using the Exer-Genie showed a greater mean gain than a circuit training program or calisthenics program.

Many physiologists believe that isotonic resistance must be limited to the largest load which can be moved at the weakest point in any range of movement. This resistance will be less than maximal during the rest of the range and will not load the muscle to its full tension developing capacity in much of its shortening range. The exercise speed is subject to considerable acceleration and it is difficult for muscles to develop maximumly throughout a complete range of motion (8, 9, 10, 12, 17, 18, 20).

In isokinetic loading, the desired exercise speed always occurs immediately. Resistance develops then as a function of the amount of tension the muscle can develop at the speed and not the reverse--resistance first, speed second--as it is in isotonic and isotonic-isometric combination exercises.

In the study of reviewed literature, one still asks the question that rises above all other factors when concerning himself with the problem of establishing a weight training program, "What is the best weight training apparatus used to develop all-around strength and flexibility in a weight training program?"

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CHAPTER III

PROCEDURES

Subjects

Thirty junior high school boys ranging in age from 12 to 14 years were selected from Newcastle Junior High School, Newcastle, Texas, representing the total population of seventh and eighth grade boys within the school system. All subjects were made aware of the purpose of the study. The subjects were made aware of the importance of maximal effort at all times during the training period and when being tested for individual test scores. Subjects were matched among groups according to their scores on the McCloy Age-Height-Weight Classification Index (5).

Testing Instruments

The measure of strength development used in this study was the Oregon Simplification of the Strength Index for Junior High School Boys. Multiple correlations between .977 and .998 were obtained between the Strength Index and various test items composing the SI battery for the different studies (1).

The testing devices used in administrating the Oregon test are: the back and leg dynamometer used in measuring the strength of both back and leg muscles; a manuometer used to measure grip strength of the right hand; regular gymnasium parallel bars to measure strength from push-ups (dips); an adjustable chinning bar used to measure pull-ups; scales to measure weight; and a stadiometer to measure height.

Tests of flexibility, or range of motion, have been proposed in the field of medicine and physical education. There are a great many instruments used today, but for the purpose of this study the goniometer was used to measure flexibility.

The goniometer is a 180-degree protractor with extended arms. The application of the goniometer is simple. The goniometer is placed parallel with the upper and lower extremities of the body, with the center of motion at the joint involved for measurement. Readings are taken with the extremity flexed as fully as the joint permits, and again with as full extension as possible; the difference between the two readings represents the range of motion (2).

Flexibility tests were made on all subjects in both the experimental and control groups. The measures were taken at the beginning and end of the six-week period. The control group was released while the experimental groups spent six weeks in the prescribed programs. The joints involved in the flexibility tests were the right and left shoulder, elbow, hip, and knee joints.

Administration of Tests

The tests were administered by this experimenter in the Newcastle Junior High School gymnasium during the final period of the school day. A pretest and posttest were administered to the thirty subjects.

Strength Tests

With subjects lined up in alphabetical order, they proceeded through five testing stations, which are as follows:

Station 1: Age, height, and weight
Station 2: Grip strength
Station 3: Back and leg strength
Station 4: Pull-ups
Station 5: Push-ups (dips)

Station 1.--At Station 1, the age, height, and weight of the individual was recorded. Age was recorded in years and months. Height and weight were measured with the subjects attired in gymnasium uniforms and recorded to the nearest half-inch and pound respectively. The McCloy Age-Height-Weight Classification Index was computed from these measures (5).

Station 2.--1. At Station 2, the right hand grip strength was measured by the tester taking the right-hand corner of the manuometer between the thumb and forefinger of his right hand and placing it in the palm of the subject's hand while holding the hand to be tested with his left hand in such a manner that the convex edge of the manuometer was between the first and second joints of the fingers and the round edge was against the base of the hand. The thumb touched, or overlapped, the first finger. The dial of the manuometer was placed face down in the hand.

2. The subject's elbow was slightly bent and his hand described a sweeping arc downward as he squeezed the manuometer.

3. The hands were not allowed to touch the body, or any object, while the test was being administered. If they did, the score was not read at all, and a retest was given after a short rest period of thirty seconds.

4. Scores were read to the nearest pound and a cake of magnesium carbonate was available for dusting the hands if they became moist and slippery. The indicator was returned to zero after each test.

Station 3.--1. At Station 3, a back and leg dynamometer was used in measuring the strength of both back and leg muscles. The outer edge of the dynamometer carries the scale for measuring lifting strength. Small pointers of white adhesive with the weight indicated on the broad ends were placed at each hundred-point interval on the dial to facilitate reading the lifts.

2. The dynamometer base was placed on a small elevated platform. It was very important that the base be solid and steady so that the subject had a feeling of stability throughout the test.

3. The handle or cross-bar was taped to facilitate firm handling by the subject, and a block of magnesium carbonate or chalk was supplied with which to dust the hands if they became moist and slippery.

4. In all lifting tests, the feet were placed parallel and six inches apart with the center of the foot opposite the chain. To save the tester's time and energy, foot outlines were painted on the base to indicate the position of the feet.

5. In back and leg lifts, the tester guarded against any snap resulting from a kink in the chain, which might have jarred the indicator beyond the true lift made by the subject.

Two methods have been proposed for administering the leg lift on the back and leg dynamometer. These methods are characterized as "without the belt" and "with the belt." Everts and Hathaway (4) perfected the belt technique in order to obtain more objective results and to improve the validity of SI battery itself. The belt technique is now advocated and has been generally adopted by physical educators as the standard technique in the administration of the test. Consequently, the leg lift with the belt only was used in this study and procedure described as follows:

1. The subject held the bar with both hands together in the center, both palms down, so that it rested at the junction of thighs and trunk. Care was taken to maintain this position after the belt was put in place and during the lift.

2. The loop end of the belt was slipped over one end of the handle or crossbar. The free end of the belt was looped around the other end of the bar, tucking it in under so that it rested next to the body. In this position, the pressure of the belt against the body and the resultant friction of the free end against the standing parts held the bar securely. The belt was placed as low as possible over the hips and gluteal muscles.

3. The subject stood with his feet in the outlined foot positions. The knees were slightly bent. Maximum lifts occurred when the subject's legs were nearly straight at the end of the lifting effort.

4. Before the subject was instructed to lift, the tester made sure that the arms and back were straight, the head erect, and the chest up. These details are of great importance to accurate testing. Subjects may err in results by from 100 to 300 or more pounds if the single detail of leg-angle is wrong. Therefore, testers repeat leg-lift tests for most subjects immediately, changing slightly the length of the chain--even by twisting, if a link seems too great.

5. The best of three tests were recorded.

Station 4.--1. The boy's pull-up test was administered from an adjustable, one inch in diameter, chinning bar which was adjusted to the subject's individual height. The bar was high enough from the floor so that the feet of the tallest boy did not touch the floor when performing the test.

2. In taking the pull-up test, the subject hung from the bar by his hands, using a forward grip, and chinned himself as many times as he could. In executing the movement, he pulled himself up until his chin was even with his hands, then lowered himself until his arms were straight. He was not permitted to kick, jerk, or use a hip motion.

3. Half-counts were recorded if the subject did not pull all the way up, if he did not straighten his arms completely when lowering the body, or if he kicked, jerked, or hipped in performing the movement. Only four half-counts were permitted.

Station 5.--1. The push-up test at Station 5 for the boys was administered on the regular gymnasium parallel bars. Regulation parallel bars were used because their width and height could be adjusted to the height of the subject.

2. The bars were adjusted at approximately shoulder height.

3. The subject stood at the end of the parallel bars, grasping one bar in each hand. He jumped to the front support with arms straight (this counts one). He lowered his body until the angle of the upper arm and forearm was less than a right angle, then pushed up to the straight-arm position (this counts two). This movement was repeated as many times as possible. The subject was not permitted to jerk or kick or stop and rest when executing push-ups.

4. At the first dip for each subject, the tester guaged the proper distance the body should be lowered by observing the elbow angle. He then held his fist so that the subject's shoulder just touched it on repeated tests.

5. If the subject did not go down to the proper bent-arm angle or all the way up to a straight-arm position, half-credit only was given, up to four half-credits.

General information about administrating the pull-up and push-up tests are as follows:

1. After four half-credits were recorded in the push-up and pull-up tests, no more were allowed for partial performance.

2. At the fifth incomplete exercise, it was best to stop the test and repeat after a rest period.

3. Counting was audible to the subject, the count being made sharply at the end of each evolution and the reason for each half-count briefly given at the time it occurred.

Scoring of the Strength Index tests was accomplished in the following manner:

Arm Strength.--Arm strength is second according to the following formula: (pull-ups + push-ups) $(\frac{W}{10} + H-60)$, in which W represents the weight in pounds, and H the height in inches. Fractions were corrected to whole numbers.

Strength Index.--The Strength Index, or SI, is the total score determined by adding together the scores made on each test item: right grip, leg strength, and arm strength, plus the factor as assigned by the Oregon Simplification of the Strength Index (1).

Flexibility Tests

With subjects lined up in alphabetical order, they proceeded through Stations 6 to 9, which are as follows:

Station 6: Right and left shoulder
Station 7: Right and left hip
Station 8: Right and left knee
Station 9: Right and left elbow

Right and left shoulder, hip, knee, and elbow measurements were made on each subject with the use of the goniometer. Degrees in measuring were read to the nearest whole degree and procedures were made as identical as possible for left and right flexibility measurement. The following is a description of procedures for flexibility measurement taken at each joint:

Station 6.--Each subject was asked to stand with his back against a vertical plane which would allow free movement for each shoulder joint. Assistants applied force to the rib cage and thigh areas, thus assuring that the subject's posterior side was absolutely against the vertical plane. The goniometer was held by the tester so that the center of the instrument was in a line, going through the shoulder joints, in a lateral plane. One lever of the goniometer was held in line with the mid-line of the subject's body below the shoulder joint, and the other lever was adjustable so as to coincide with the subject's range of motion. The subject was then asked to raise his extended arm as far forward and backward as his joint would permit, at all times being sure not to force flexibility beyond a false range of motion.

Station 7.--Each subject was asked to stand with his back against a vertical plane which would allow free movement for each hip joint. Assistants applied force to the knee of the leg supporting the body and against the rib cage area, assuring the subject's posterior side was against the vertical plane. The goniometer was held by the tester so that the center of the instrument was in a line, going through the hip joints, in a lateral plane. One lever of the goniometer was held in line with the mid-line of the subject's body, below the hip joint, and the other lever was adjustable to coincide with the subject's range of motion. The subject was asked to raise his extended leg as far forward and backward as his normal range of joint motion would permit.

Station 8.--Each subject was asked to lie in a supine position, at which time the subject flexed his knee for a dial reading and then extended his knee for a second reading to determine the total range of motion for each knee joint. The tester held the goniometer in a horizontal position with one lever held stationary with the middle of the side of the upper leg and the other lever adjusted to the flexion and extension of each knee joint. The center of the instrument was held in a lateral plane with the knee joint.

Station 9.--Each subject was asked to lie in a supine position at which time the subject flexed his elbow for a dial reading and then extended his elbow for a second reading to determine total range of motion for each elbow joint. The tester held the goniometer in a horizontal position with one lever held stationary with the midline of the upper arm and the other lever adjusted to the flexion and extension of each elbow joint. The center of the instrument was held in a lateral plane with the elbow joint.

Experimental Equipment

The Exer-Genie and the Super-Mini-Gym were used by the two groups and served as the weight training apparatus for this study. The Super-Mini-Gym was also used for a dynamometer in determining amount of weight to progressively add to individual subjects in Group II. A description of each apparatus is as follows:

The Exer-Genie and the Super-Mini-Gym operate on the same principle--a rope wound around a metal core several times so that a constant resistance is provided. The resistance can be varied from nothing up to around 600 pounds.

The theory behind the Exer-Genie portable gym is that isometrics and isotonics are combined to provide a nearly perfect combination exercise. In the resistive exercise or isometric part of the program, the overload principle is used. No movement is permitted while one strains against the device for ten seconds. The theory behind the Super-Mini-Gym is strictly that of isokinetic resistance by using an isokinetic exercise providing constant resistance throughout the joint and muscle's full range of motion. Both devices operate when the rope is pulled through a long range of movement.

Usually used with these devices are three basic stances. The most frequent is fastening the device to a stirrup bar or board upon which one stands. Then the ropes are pulled upward. Or one can attach the device to a door by means of a nylon strap. The strap is slipped through the crack near a hinge and the door is closed on it. Finally, one may do abdominal pulls and a variation of rowing by attaching one end to a foot and holding the other end in the hands. With those three basic set-ups, it is possible to duplicate every kind of weight training exercise used for this study.

Research Design

The thirty subjects were placed into three groups. All groups participated in track and field activities during the entire testing period. Group I used, throughout the six-week period, the Super-Mini-Gym as their weight training apparatus. Group II used the Exer-Genie as their weight training apparatus. Group III did not use any kind of weight training device or participate in any weight training program.

Groups I and II were in a six-week training program. Each of these groups performed three selected exercises: squats, curls, and the bench press. A description of the exercises are as follows:

1. Squats: Groups I and II started in a squat position and with leg power straightened to a vertical position. Group II performed a ten-second isometric hold before each exercise was begun.

2. Curls: Both Groups I and II had their device in a position in front of the body with arms straight downward and then pulled to a position against the chest and then back to the original position in a complete curl. Group II completed a ten-second isometric hold before completing the exercise.

3. Bench-Press: The bench-press consisted of pressing the resistance developed by the Exer-Genie and Super-Mini-Gym from a supine position on a bench. Group II started with the bar at chest level and before doing the exercise completed a ten-second isometric hold.

Subjects in Group II, before the start of the program and at the start of each week during the six-week program, obtained a maximum poundage for each exercise performed. To assure that increases in the number of pounds were kept exactly proportional to the subject's ability, each week, each subject in Group II performed each exercise one time to obtain a maximal strength graph which was produced by the Achiever Model Super-Mini-Gym. This is an accurate graph representing the maximal strength of the subject during each exercise performed. Then the results of the graphs were used by subjects in Group II to adjust the apparatus each one used for maximal resistance for that particular week. This procedure was done at the start of each week during the weight training program. Group I using the Super-Mini-Gym, did not need to perform any adjustments to increase resistance because this principle is taken care of automatically within the weight device.

Groups I and II performed three sets of two repetitions of each exercise during the first and second weeks. In beginning the third and throughout the fourth week, Groups I and II performed three sets of three repetitions. During the fifth and final week, Groups I and II for each selected exercise performed three sets of four repetitions, completing the six-week training program for this study. Groups I and II performed the selected exercises on Monday, Wednesday, and Friday of each week during the six-week weight training program. A pretest and posttest were given to the three groups using the testing instruments and procedures described earlier in this chapter.

Statistical Analysis

Comparisons were made between the three groups involved in this study by analysis of covariance. The Tukey test was used where significant F ratios developed.

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CHAPTER IV

PRESENTATION AND ANALYSIS OF DATA

It was the purpose of this study to examine and investigate strength and flexibility development as each is affected by three training programs using two apparatus: the Exer-Genie and the Super-Mini-Gym. Data were collected from thirty junior high students enrolled in Newcastle Junior High School, Newcastle, Texas. All subjects, while participating in the prescribed programs, participated in track and field. The students were matched in three groups according to McCloy's (1) Age-Height-Weight Classification Index. Each subject was pretested and posttested on four strength measures and eight flexibility measures. Computation of a Strength Index was achieved using the four strength measures. The data obtained from these tests served as the basis for the findings of the study.

Statistical treatment of the data was accomplished through analysis of covariance. The F ratios achieving significance at the 0.05 level of confidence were further subjected to a significance test between individual group means according to Tukey's method (2). The 0.05 level of confidence was also selected for the Tukey comparisons.

Results of the Study

Data collected for the study are related to track and field training programs supplemented by weight training activities. The program for Group I (Super-Mini-Gym) consisted of participation in track and field activities supplemented by a weight training routine using the Super-Mini-Gym. The program for Group II (Exer-Genie) consisted of participating in track and field activities supplemented by a weight training routine using the Exer-Genie. The control group (Group III) consisted only of participation in track and field activities.

The results of the study are shown in Tables I through VII. Table I reports group means and standard deviations of pretests and posttests scores for Group I (Super-Mini-Gym). Table II reports group means and standard deviations of pretests and posttests scores for Group II (Exer-Genie). Table III reports group means and standard deviations of pretests and posttests scores for Group III (Control).

The study focused on the answering of several questions. Question One asked whether Group I (Super-Mini-Gym) would develop a significantly greater mean strength gain than either Group II (Exer-Genie) or Group III (Control). Three strength measures, grip strength, dip strength, and Strength Index, showed significant F ratios. These F ratios are reported in Table IV. Application of the Tukey comparison of group means did not indicate significance in a direction favoring Group I.

TABLE I

GROUP MEANS AND STANDARD DEVIATIONS OF PRETEST AND POSTTEST SCORES FOR GROUP I (SUPER-MINI-GYM)

Test Items	Pretest Mean	Pretest Standard Deviation	Posttest Mean	Posttest Standard Deviation
STRENGTH INDEX ITEMS:				
Leg Lift	185.00	57.55	205.00	55.79
Right Grip	73.11	21.48	67.33	11.87
Chins	4.11	3.82	6.55	5.77
Dips	2.55	3.57	3.22	4.30
STRENGTH INDEX	791.89	191.55	825.78	167.47
FLEXIBILITY ITEMS:				
Left Shoulder	226.11	16.49	232.89	15.86
Right Shoulder	232.89	14.46	237.78	17.26
Left Hip	88.78	11.60	95.89	11.21
Right Hip	91.78	8.04	92.89	11.99
Left Elbow	144.22	6.26	144.55	6.82
Right Elbow	146.67	5.68	145.22	6.28
Left Knee	141.11	6.23	143.22	5.87
Right Knee	141.00	5.12	143.11	5.37

TABLE II

GROUP MEANS AND STANDARD DEVIATIONS OF PRETEST AND POSTTEST SCORES FOR GROUP II (EXER-GENIE)

Test Items	Pretest Mean	Pretest Standard Deviation	Posttest Mean	Posttest Standard Deviation
STRENGTH INDEX ITEMS:				
Leg Lift	157.00	40.71	171.00	49.24
Right Grip	63.67	9.47	64.44	10.51
Chins	5.22	2.73	9.55	5.03
Dips	2.44	3.21	4.55	4.27
STRENGTH INDEX	716.67	110.99	811.56	143.49
FLEXIBILITY ITEMS:				
Left Shoulder	231.11	8.85	241.22	17.83
Right Shoulder	231.33	8.54	237.44	20.32
Left Hip	94.44	12.23	102.22	9.35
Right Hip	96.00	5.50	100.44	10.77
Left Elbow	145.11	4.51	148.22	4.23
Right Elbow	144.33	4.61	148.22	4.71
Left Knee	144.44	3.28	147.55	4.00
Right Knee	143.67	2.87	147.83	3.94

TABLE III

GROUP MEANS AND STANDARD DEVIATIONS OF PRETEST AND POSTTEST SCORES FOR GROUP III (CONTROL GROUP)

Test Items	Pretest Mean	Pretest Standard Deviation	Posttest Mean	Posttest Standard Deviation
STRENGTH INDEX ITEMS:				
Leg Lift	136.00	27.57	156.00	36.18
Right Grip	58.80	15.95	54.20	10.55
Chins	1.80	1.87	4.00	3.55
Dips	0.20	0.42	1.10	1.19
STRENGTH INDEX	606.10	103.55	627.50	96.18
FLEXIBILITY ITEMS:				
Left Shoulder	232.70	12.85	234.70	13.81
Right Shoulder	240.00	12.94	233.70	11.89
Left Hip	93.30	14.22	91.50	6.40
Right Hip	90.10	13.80	95.90	8.53
Left Elbow	149.30	3.77	151.90	4.46
Right Elbow	147.80	4.10	148.60	3.30
Left Knee	148.20	4.80	147.10	3.73
Right Knee	146.40	4.27	147.80	3.94

TABLE IV

ANALYSIS OF COVARIANCE FOR STRENGTH INDEX ITEMS, STRENGTH INDEX, AND FLEXIBILITY MEASURES: COMPARISON OF THREE TRAINING PROGRAMS

Test Items	Group I Adjusted Mean	Group II Adjusted Mean	Group III Adjusted Mean	Mean Square Within	Mean Square Between	F	P
STRENGTH INDEX ITEMS:							
Leg Lift	181.24	172.55	176.59	744.55	159.30	0.21	0.81
Right Grip	62.76	65.17	57.66	37.62	135.59	3.60*	0.04
Chins	5.87	7.24	6.69	3.55	4.28	1.20	0.31
Dips	2.14	3.61	2.91	1.09	4.86	4.48*	0.02
STRENGTH INDEX	746.06	798.07	711.38	3897.05	16693.53	4.28*	0.03
FLEXIBILITY ITEMS:							
Left Shoulder	235.46	240.55	232.99	186.07	138.88	0.75	0.51
Right Shoulder	238.87	239.36	230.99	245.21	192.16	0.78	0.52
Left Hip	96.52	101.81	91.30	80.64	261.62	3.24	0.05
Right Hip	93.14	99.31	96.70	102.84	84.30	0.82	0.54
Left Elbow	146.43	149.30	149.24	8.92	22.86	2.56	0.10
Right Elbow	145.88	149.10	147.22	14.42	23.43	1.62	0.22
Left Knee	145.51	147.73	144.90	11.90	20.24	1.70	0.20
Right Knee	145.28	147.42	145.77	9.55	11.40	1.20	0.32

*Significant F ratio at .05 level of confidence. Value of 3.40 required for significance at the .05 level of confidence.

Question Two asked whether Group II (Exer-Genie) would develop a significantly greater mean strength gain than either Group I (Super-Mini-Gym) or Group III (Control). Of the three significant F ratios identified in analysis of covariance of the strength measures data, dip strength was found to be developed to a significantly greater level by the Exer-Genie group than by the Super-Mini-Gym group. The Group I (Super-Mini-Gym) pretest mean for dip strength was 2.55 with a standard deviation of 3.57 and the posttest mean was 3.22 with a standard deviation of 4.30. The Group II (Exer-Genie) pretest mean for dip strength was 2.44 with a standard deviation of 3.21 and the posttest mean was 4.55 with a standard deviation of 4.27. Table IV reports the Group I adjusted mean as 2.14 and the Group II adjusted mean as 3.61. The mean gain of Group II was significantly greater than the mean gain of Group I as indicated by use of the Tukey method of comparison of group means. The F ratio of 4.48 was significant at the .05 level of confidence and the further Tukey comparison, as shown in Table V yielded a value of 4.11. A value of 3.53 is required for significance at the .05 level.

Grip strength development was also significantly increased for Group II (Exer-Genie) in comparison with Group III (Control). The Group II (Exer-Genie) pretest mean for grip strength was 63.67 with a standard deviation of 9.47 and the posttest mean was 64.44 with a standard deviation of 10.51.

TABLE V

COMPARISON OF GROUP MEANS OF DIP STRENGTH
USING THE TUKEY METHOD

Groups	Adjusted Mean	Groups I	II	III
I (N=9)	2.14	0.00	-4.11	-2.15
II (N=9)	3.61	4.11*	0.00	1.95
III (N=10)	2.91	2.15	-1.95	0.00

*A value of 3.53 on Tukey's test is required for significance at the .05 level of confidence.

The Group III (Control) pretest mean for grip strength was 58.80 with a standard deviation of 15.95 and the posttest mean was 54.20 with a standard deviation of 10.55. Table IV reports the Group II adjusted mean as 65.17 and the Group III adjusted mean as 57.66. The mean gain of Group II was significantly greater than the mean gain of group III as indicated by use of the Tukey method of comparison of group means. The F ratio of 3.60 was significant at the .05 level of confidence and the further Tukey comparison, as shown in Table VI, yielded a value of 3.60. A value of 3.53 is required for significance at the .05 level.

Strength Index mean gain was found to have a significant F ratio identified by analysis of covariance. The Group II (Exer-Genie) pretest mean for Strength Index was 716.67 with a standard deviation of 110.99 and the posttest mean was 811.56 with a standard deviation of 143.49. The Group III (Control) pretest mean for Strength Index was 606.10 with a

TABLE VI

COMPARISON OF GROUP MEANS OF GRIP STRENGTH
USING THE TUKEY METHOD

Groups	Adjusted Mean	Groups I	II	III
I (N=9)	62.75	0.00	-1.15	2.44
II (N=9)	65.17	1.15	0.00	3.60*
III (N=10)	57.66	-2.44	-3.60	0.00

*A value of 3.53 on Tukey's test is required for significance at the .05 level of confidence.

standard deviation of 103.55 and the posttest mean was 627.50 with a standard deviation of 96.18. Table IV reports the Group II adjusted mean as 798.07 and the Group III adjusted mean as 711.38. The mean gain of Group II was significantly greater than the mean gain of Group III as indicated by use of the Tukey method of comparison of group means. The F ratio of 4.28 was significant at the .05 level of confidence and the further Tukey comparison as shown in Table VII, yielded a value of 3.91. A value of 3.53 is required for significance at the .05 level of confidence.

Question Three asked whether Group III (Control group) would develop a significantly greater mean strength difference when compared to Group I (Super-Mini-Gym) or Group II (Exer-Genie). Application of the Tukey comparison of group means of strength measures yielding significant F ratios did not indicate significance in a direction favoring Group III.

Question Four asked which of the three training programs could cause a change in flexibility. Table IV reports the

TABLE VII

COMPARISON OF GROUP MEANS OF THE STRENGTH INDEX USING THE TUKEY METHOD

Groups	Adjusted Mean	Groups I	II	III
I (N=9)	746.06	0.00	-2.34	1.56
II (N=9)	798.07	2.34	0.00	3.91*
III (N=10)	711.37	-1.56	-3.91	0.00

*A value of 3.53 on Tukey's test is required for significance at the .05 level of confidence.

results of analysis of covariance for eight flexibility items and indicates a lack of significant F ratios at the .05 level of confidence. None of the training programs used in this investigation caused a significantly greater change in flexibility.

Question Five asked which of the three programs is most desirable with regard to strength and flexibility changes. Table IV reports the analysis of covariance for strength and flexibility measures, comparing the three training programs used in this investigation. Although three F ratios resulted from analysis of covariance of the strength measures, further group mean comparisons showed that Group II (Exer-Genie) was either superior to Group I (Super-Mini-Gym) or to Group III (Control), but never superior to both Group I and Group III on a single measure. When concentrating on flexibility measures, none of the items showed significant F ratios. Therefore, no certain group in this investigation showed as being a superior training program with regard to changes in flexibility.

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CHAPTER V

SUMMARY, CONCLUSIONS, AND RECOMMENDATIONS

Summary of the Study

Weight lifting is known to be of ancient origin and according to legend, Egyptian and Chinese athletes, nearly 5,000 years ago, demonstrated feats of strength. "Strength, muscular endurance, and muscular size increase, within limits, in response to repetitive exercise against progressively increased resistance." (2) This is known as the "overload principle" and is the basis for most progressive resistance exercise and weight training programs. To distinguish between weight training and weight lifting; weight training is a method of improving muscular strength, endurance, and flexibility using any one of a variety of weight training apparatus. Many different and unique apparatus in weight training programs are on the market today. Physiologists seem to agree that the best way to develop strength, using these devices, is by a combination of isotonic and isometric muscular contractions. Others seem to agree that the use of isokinetic muscular contractions is best. There are a variety of weight training apparatus which employ one or a combination of the above muscular contractions. The question consistently arises as to which weight training apparatus is the best to use in developing gains of strength and flexibility.

The purpose of this study was to investigate strength and flexibility development as each is affected by three training programs using two apparatus: the Exer-Genie and the Super-Mini-Gym.

Thirty subjects were matched into three groups using McCloy's Age-Height-Weight Classification Index (1). During the experiment two subjects were lost due to illness and transfer. Groups I and II had nine subjects each and Group III ended the experiment with the original number, ten. All subjects participated in track and field while under going the six-week supplementary weight training programs. Group I performed the leg press, curls, and the bench press using the Super-Mini-Gym apparatus on Mondays, Wednesdays, and Fridays, each week, for six weeks. Group II performed the leg press, curls, and the bench press using the Exer-Genie apparatus on Mondays, Wednesdays, and Fridays, each week, for six weeks. The beginning number of sets and repetitions were the same for both groups throughout the experiment, starting with three sets of two repetitions the first and second week and ending with three sets of four repetitions during the fifth and final week. The pretest and posttest were given under the same conditions and within the six-week training period. The pretest and posttest consisted of testing for a Strength Index using leg strength, right grip strength, dip strength, and chin strength measures. Flexibility measures were taken for each subject consisting of right and left hip, knee, shoulder, and elbow joints; making eight flexibility measures used in this study.

Statistical treatment of the data was accomplished by the analysis of covariance. The .05 level of confidence was selected as the significance rejection level.

Conclusions

An analysis of the data warrants the drawing of the following conclusions:

1. Grip strength can be increased to a significantly greater level by using the Exer-Genie supplementary weight training program with participation in track and field activities.

2. Dip strength can be increased to a significantly greater level by using the Exer-Genie supplementary weight training program with participation in track and field activities than by using the Super-Mini-Gym supplementary weight training program with participation in track and field activities.

3. Strength Index scores can be increased to a significantly greater level by using the Exer-Genie supplementary program with participation in track and field activities than by participation in track and field activities only.

4. Flexibility cannot be significantly differently affected by any one of the three programs undertaken in this study.

5. Three significant F ratios resulted from analysis of covariance of the strength measures but further group mean comparisons showed that no group was superior to the other two groups on a single measure. When comparing flexibility measures, none of the items showed significant F ratios. Therefore, no certain group in this investigation showed as being a superior training program with regard to changes in flexibility.

Recommendations

Based on the findings and conclusions of this study, the following recommendations are presented:

1. For the development of strength, either the Exer-Genie or Super-Mini-Gym will accomplish strength gains. Results of this study show that no particular group involved in the six-week weight training program is superior.

2. A study should be conducted using a larger number of subjects in each group and more than three groups.

3. The use of more than two weight training apparatus should be used to serve as as aid to coaches, physical educators, or individuals interested in acquiring an apparatus most helpful in developing components of physical fitness and strength. Examples of others are the Universal Gym, barbells, and the Douglas Gym.

4. It would be of benefit to include more than one component of physical fitness to secure a total overview of physical fitness and strength developed by a weight training program.

5. Periodic posttests should be administered to determine which group or groups retain the highest level of physical fitness and strength over varied periods of time after completion of the initial investigation.

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