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# A Comparison of the Exer-Genie as a Physical Conditioning Device to Traditional Methods of Exercise

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# A COMPARISON OF THE EXER-GENIE AS A PHYSICAL CONDITIONING DEVICE TO TRADITIONAL METHODS OF EXERCISE

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A Thesis

Presented to

the Graduate Faculty

Central Washington State College

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In Partial Fulfillment

of the Requirements for the Degree

Master of Education

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by

Robert E. Parsons

August, 1969

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# CHAPTER I

## THE PROBLEM AND DEFINITIONS OF TERMS

The technological advancement of our nation has brought great pressure on educators to develop school physical education programs which will enable youth to maintain optimum levels of physical fitness. The increased reliance upon automation makes this endeavor that much more challenging. The late President Kennedy, in an article for *Sports Illustrated*, showed concern for this problem when he stated:

> One look at the packed parking lot of the average high school will tell us what happened to the traditional hike to school that helped build young bodies (27:15-17).

It has become increasingly more difficult for parents to direct young people into activities which demand physical strength and dexterity. Strenuous physical chores are no longer required for the maintenance of most family homes today. Such physical exercise as chopping wood, or spading the garden have been relatively discontinued in our industrial society. Directed exercise is needed as attested by physical education authorities such as Clarke, who said:

> . . . the right kind and amount of exercise will develop muscular strength and endurance, body flexibility, and circulatory-respiratory endurance. In fact, properly directed exercise is the only known means for acquiring the ability to engage in tasks demanding sustained physical effort (11:105).

The President's Council on Physical Fitness and Sports stated that the advancement of technological development has reduced our daily muscle effort and school programs should be maintained so that all pupils may obtain a high degree of physical fitness. The Council also pointed out that special attention should be focused on those children who are physically underdeveloped. Many times the needs of the underdeveloped have been neglected, whereas these children require a great deal of attention and special training. The Council also noted the school physical education program as offering the best means of reaching these children (34:i-10).

Educators are concerned about possible relationships between motor development and academic achievement. Recent studies conducted show the relationship between physical fitness and academic success. Hart and Shay discussed this in their study of physical fitness and academic achievement of college sophomore women:

> Although physical fitness is not a general predictor of academic success, it is high enough to be considered as a necessary factor for the improvement of academic index in the general education of the college student (21:433).

Weber, in an investigation of college freshmen, reported a significant correlation of .41 between physical fitness scores and grade point averages (42:471-474).

Irving studied the grade point average, absence from school due to illness, and citizenship grades in the La

Sierra High School in suburban Sacramento, California. The boys used in the study were grouped in physical fitness categories known as the "color system." Conclusions reached by the researcher indicated the following:

> . . . (1) boys in the higher physical fitness groups received much more than their share of higher grades than chance would account for; (2) boys in the higher physical fitness groups were absent from school less due to illness, than the less fit boys; (3) far fewer boys from the lowest fitness level were in the upper 25 per cent of their classes academically than chance alone could account for; and finally (4) the minor changes in academic grade averages from semester to semester could be accounted for by chance but the progressive increase in physical fitness levels were far in excess of chance occurance (25).

There are many methods and techniques used to improve physical fitness. One of the most widely used methods is resistive exercise. Such exercise includes isometric tension in which the force exerted contracts muscles without moving the bodily segments. In other words, the muscle length remains the same.

Also used is isotonic tension in which the muscle contraction involves movement where the length of the muscle changes. McCraw and Burnham found in their study of three groups of college men, that no single method is adequate in achieving maximum development of both strength and endurance. They further discovered that strength may be improved by either isometric or isotonic training, but muscular endurance as investigated in this study, was best developed by repeated rapidly executed contractions of the muscle performed against a reasonably heavy load (31:79-87).

A current theory of exercise is to tire the muscle isometrically without allowing the muscle to recover from fatigue, and then move with controlled resistance through a complete range of motion. The Exer-Genie is a conditioning device which lends itself well to this type of exercise (17).

The Exer-Genie, a physical conditioner which provides for both isotonic and isometric exercises, was used in this study in an effort to determine its effectiveness with students needing special attention in body conditioning and strength development.

## I. THE PROBLEM

The basic question investigated in the study was the comparative effectiveness of the Exer-Genie as an instrument for the improvement of strength.

### Statement of the Problem

This study was composed of two problems as follows:

1. To compare the Exer-Genie with a traditional developmental physical education program and a typical physical education program for developing physical fitness in elementary school boys.

2. To compare the development of specific muscular strengths in a program using the Exer-Genie with the

development of the same specific muscular strengths in a traditional developmental program.

## Scope of the Study

For the purposes of this investigation, three physical exercise groups were used as subjects consisting of fourth, fifth, and sixth grade boys who scored ninety or below on the modified form of the Oregon Physical Fitness Index (P.F.I.) test. The students were divided into three groups: experimental group A using the Exer-Genie; experimental group B using the traditional developmental exercises; and control group C which was a typical elementary physical education program.

The Oregon P.F.I. test was used to identify sub-fit boys for groups A, B, and C. Pre-test results were compared with post-test results to determine the significance of differences between the three groups. To further compare the Exer-Genie with the traditional conditioning program, individual muscle groups were tested by four cable tensiometer strength tests to compare the significance of difference between experimental groups A and B.

The study took place over a ten week period during January, February, and March, 1969.

## Importance of the Study

Educational authorities are constantly applying results of research in physical education in an attempt to improve the physical well-being of our nation's citizenry. It was felt that this study would add insight into the use of the Exer-Genie as a tool for physical conditioning.

This study was undertaken because of the writer's interest in an innovative device which utilizes both isotonic and isometric exercises. As a physical educator, the writer's special concern for students lacking in physical fitness led to an exploration of new techniques and new devices for better teaching methodology. Through personal use of the Exer-Genie, the benefits of such a conditioning device were realized.

With this in mind, it was anticipated that knowledge of the usefulness of the Exer-Genie as a physical conditioning device would be beneficial to those administrators and instructors of physical education who endeavor to improve upon traditional teaching programs.

The concept of the Exer-Genie as an effective tool in physical conditioning is relatively new. Therefore, published research data is limited. A basic purpose of this study was to provide data concerning the utility of the Exer-Genie which would better enable educators to determine its effectiveness in the physical education program.

## Limitations of the Study

1. The study was limited to those boys scoring below ninety on the P.F.I. in the elementary schools of Ellensburg, Washington and Kittitas, Washington. Only fourth, fifth, and sixth grade boys were tested.

2. Experimental groups A and B were limited to Ellensburg elementary schools.

3. The regular physical education group C was composed of boys from the Kittitas elementary school.

4. The study was limited to a ten week period of time during January, February, and March of 1969.

## Basic Assumptions

1. It is assumed that all those participating in the study did their best while taking the physical fitness tests and while participating in their respective physical education classes.

2. It is assumed that outside activities could neither be limited or controlled and further, that their effects would be equally distributed among the three groups.

# II. DEFINITION OF TERMS

For the purposes of this study, the following definitions and descriptions will apply to the terms noted:

## Cable Tensiometer

An instrument designed to measure the tension existing on a cable stretched taut between two anchor points. The instrument is more fully described in Chapter II.

Cable Tensiometer Strength Test

This was an established battery of four tests statistically selected for their high relationship to a larger battery of eighteen tests which adequately represented the muscular strength of the entire body.

Exer-Genie

The Exer-Genie is a device that operates free from gravity but uses the friction technique for resistive means. The Exer-Genie combines isometric as well as isotonic contraction to facilitate muscle conditioning. The complete philosophy and utilization of the Exer-Genie is further explained in Chapter II.

Isometric Exercise

Isometric exercise is a contraction where the muscle fibers receive the nerve stimulus and all the intra-muscle metabolism is initiated, but because of the nature of the resistance, there is no shortening of the fibers (33:57-58).

Isotonic Exercise

Isotonic exercise is a contraction wherein the muscle fibers shorten during the work (33:57-58).

Muscular Strength

The tension which the muscles can apply in a single maximum contraction (11:4).

<u>Oregon Simplification of Rogers' Physical Fitness Index Test</u>

This test will be referred to as the Oregon P.F.I. test which is a briefer version of the original Rogers' Strength Index test, consisting of leg lift, back lift, and dips executed on parallel bars. Complete information on the test is found in Chapter II.

<u>Physical Fitness</u>

Clarke defines physical fitness as follows:

> Physical fitness is the development and maintenance of a strong physique and soundly functioning organs, to the end that the individual realizes his capacity for physical well being, unhampered by drains or by a body lacking in strength and vitality (14:24).

<u>$T_1$</u>

$T_1$ denotes the scores taken by testing at the beginning of the study and before participation in the physical education programs.

<u>$T_2$</u>

$T_2$ denotes the measurements taken at the end of the scheduled ten week period.

## III. ORGANIZATION OF REMAINDER OF STUDY

Chapter II reviews literature pertaining to isotonic and isometric conditioning. In addition, the review of literature presents and summarizes information about the cable tensiometer and the evolution of the instrument and the test battery used in this study. The development and use of the Exer-Genie is presented and the simplified version of the original Rogers' Strength Index, as used herein, is clarified.

Chapter III describes the methods and procedures used in this study. Chapter IV presents the analysis of the data. Chapter V presents a summary of the investigation, conclusions reached, and recommendations made by the researcher.

# CHAPTER II

## REVIEW OF LITERATURE

### I. CABLE TENSIOMETER STRENGTH TEST

The test for strength of a muscle has been with us for centuries. Hunsicker and Donnelly reported on the various instruments which have been used to measure human strength for the last 250 years (23:408).

De La Hire, the French scientist, conducted the first scientific study of man's strength by comparing the strength of men lifting weights and carrying burdens with that of horses performing the same task in 1699. Since that time, many different pieces of apparatus have been manufactured to measure the strength of man. Graham was the first person to use such an instrument given the name of dynamometer. In 1807, Regnier produced the first spring steel dynamometer in use today. Sargent started the use of dynamometers in the United States while at Harvard University in the last quarter of the 19th Century. The dynamometer, especially the spring steel type, has been the principle instrument utilized for strength testing. Many different types of dynamometers have been developed since Regnier first introduced his instrument in 1807. The spring steel dynamometers today are slightly different in design but they are all based upon the same principle, deformation of a piece of steel either in the form of a ring, ellipse, or coil with the deformation of the metal being proportional to the force applied (23:408-420).

Clarke and Peterson, working in orthopedic reconditioning therapy during World War II at the Army Air Force Convalescent Hospital, Bowerman Field, Kentucky, investigated several different types of strength testing devices. This was done in an attempt to develop an apparatus and an objective technique for measuring the strength of affected muscle groups involved in orthopedic disabilities. After considerable research, the tensiometer instrument was selected as having the greatest advantage for their purpose of testing strength of muscles for work in rehabilitation. This instrument was described by Clarke as follows:

> The tensiometer is a small compact unit (4" x 4" x 1¼") designed for testing the tension of aircraft cables. Cable tension is determined by measuring the force needed to create offset (on riser) in the cable between two set points (the sectors). The cable tension may be converted directly into pounds on a prepared calibration chart attached to the inside cover of the tensiometer case (9:118).

Because the tensiometer is designed to measure the tension on an already taut cable, it was found that the instrument was not entirely accurate in measuring the pulling force of a cable. The engineers of the Pacific Scientific Company, manufacturers of the tensiometer, recalibrated the tensiometer used in Clarke and Peterson's work so this function could take place accurately (9:118-147).

Clarke and Peterson originally started their work with an instrument which measured cable tension up to 300 pounds. This instrument was found to be inaccurate below 30 pounds so it was necessary to obtain a more sensitive instrument that would measure between 5 and 100 pounds of tension for measurement of small muscle groups. It was also found that an instrument measuring 200 pounds is adequate for the stronger muscle pulls encountered (9:118-147).

Clarke and Peterson described their pulling apparatus as follows:

1. Cable: two flexible cables one-sixteenth inch in size were used. They were 7 x 7 three feet six inches and six feet six inches long.
2. Strap: an adjustable strap was used for the purpose of placing around the patient's limb when pulling.
3. Testing Table: A plinth that is six feet six inches long, two feet nine inches wide and two feet six inches high was needed for placing the patient in correct position for the various pulls (9:120).

In an attempt to determine the objectivity coefficient for each of the twenty-eight orthopedic tests used, sixty-four non-disabled male students at Springfield College were studied by Clarke and Peterson. Two graduate students, Muller and Parker, did the testing. They administered each of the twenty-eight tests separately to the sixty-four students chosen at random. The students were divided into groups of six to eight for ease of administration of the test. The same group was tested on the same day by each investigator. Following the testing, a product-moment coefficient of correlation was computed between the scores of the two testers for the sixty-four subjects and the twenty-eight different tests. It was found that twenty-two of the tests had objectivity coefficients of .92 and above, of which twelve were between .95 and .97. Six of the tests were found to have coefficients lower than .90, but no test was found to be lower than .84 (9:118-147). The researchers stated:

> As .90 is the accepted standard indicating desirable objectivity and as tests with coefficients as low as .80 may be used for individual measurement, none of the 28 tests studied should be considered sufficiently unsatisfactory to warrant elimination from the battery (9:120).

The six tests that showed an objectivity coefficient below .90 were reevaluated by Bailey and Neff, also graduate assistants at Springfield College. Through revisions of the test procedures, Bailey and Neff raised those objectivity coefficients above .90. All of Clarke and Peterson's tests were based on certain movements of the wrist, elbow, shoulder, hip, knee and ankle (9:121).

Attempts were made to improve upon the twenty-eight tensiometer strength tests developed by Clarke and Peterson. Sixteen additional joint movements were researched. Also adding to the improvements of the tensiometer, a maximum pointer was placed on the dial to facilitate reading the subject's score (8:399-419).

The improvement of the tensiometer strength testing method came about by three studies. The first study was the effect of alternate body positions, the second study was the selection of proper joint angles and the third study was the location of the strap positions. Harrell attempted to alternate positions of twelve of the original tests in order to eliminate awkwardness, special testing equipment and to provide the best kinesiological positions for muscles to function (8:399-419).

DePasquale and Mathews attempted to improve the joint angles of the original research done by Clarke and Peterson. The joint angles had been selected empirically after a brief trial of two or more positions. The researchers put the joint through a full range of motion. When the joint could be put through a 180 degree motion, fewer angles were used. Graphs were made for each angle tested, showing the muscle power exerted through the range of motion. The point highest on the graph gave an indication of the greatest amount of strength realized from the muscle tension, consequently this was the angle selected for each test (8:399-419).

DePasquale and Mathews also explored the position of the strap to be used in cable tensiometer testing. In the original tests of Clarke and Peterson, the strap was placed midway between the two joints with the exception of the extension of the hip and inward and outward rotation of the hip. DePasquale and Mathews used the results of the tensiometer test to determine these locations more exactly. The muscle strength exerted at alternate strap positions for twelve of the original tests were then determined (8:399-419).

The results of these three studies helped improve the tensiometer testing methodology by pointing out the following selected findings: The study of the elbow flexion angle showed a selection of 115 degrees. The strap study pointed out a twenty-five pound difference between a strap at the mid-position and a strap at the distal position so the original mid-point selection was continued. The only change in the elbow flexion test was the 115 degree angle at the elbow from the 90 degree original angle. Elbow extension was studied and the only change in the testing process was the change of the angle at the elbow from 160 degrees to 40 degrees. The shoulder adduction test was changed to eliminate the effects of the biceps muscle. The humerus was rotated inward by turning the forearm across the chest and the hand was held low toward the opposite shoulder. The angle at the shoulder joint was changed to 110 degrees from 160 degrees. The results of the study of the shoulder adduction showed that the shoulder joint angle should be changed to 180 degrees from 110 degrees and the position of the pulling strap was changed to the distal end of the limb acting as a fulcrum for movement. The shoulder flexion test was changed by increasing the angle at the shoulder to 240 degrees from 135 degrees. Shoulder extension test changed the angle of the joint from 135 degrees to 90 degrees. Shoulder inward rotation was not changed and shoulder outward rotation was not changed. Hip flexion test was changed by placing the hip in 90 degree flexion and also recommended that the actual weight lifted by the muscles should be added to the weight of the limb. Hip extension was changed with the hip in 50 degree flexion. Hip adduction was changed placing the hip in 180 degree adduction. Knee extension test was changed placing the knee in 165 degree flexion. Ankle dorsal flexion was changed in placing the angle at 125 degrees. Ankle plantar flexion was changed by placing the angle at 90 degrees (8:399-419).

As continued improvements in tensiometer strength testing were established, new methods in testing were reported by Clarke, Baily, and Shay. They developed sixteen new strength tests that would include movements of the fingers, thumb, neck and trunk as well as some additional work done in the movements of the wrist, shoulder and ankle. The investigators also reported on new findings and techniques used in the hip test. While developing the new tests they devised new equipment and tested it. The pulling apparatus made of six feet of 1/16 inch cable was simplified by using a shorter piece of cable and attaching it to a welded link of chain 1½ x ½ inches. A double harness snap replaced the old adjustable bar attachment (12:136-147).

With the construction of the sixteen new tests, new equipment was necessary to carry out the tests. The upper trunk harness, finger strap, trunk strap and an arm rest chair were also devised. The testing table was revised to allow for trunk and hip testing by cutting a slit in it twenty inches x seven inches beginning ten inches from one end of the table. Hooks were also attached to the frame under the table for ease of fastening the chain (12:136-147).

In an effort to compare the more widely used strength measuring instrument for effectiveness in measuring strength, Clarke undertook a study to compare the effectiveness for measuring muscle strength for the following four instruments: Wakim-Porter strain gauge, spring scale, cable tensiometer and Newman myometer. In order to test the instruments for weak and small muscle exertion, six tests were used. The weak muscle movements tested the finger flexion, wrist dorsal flexion, shoulder outward rotation, and neck extension. For the strong muscle movements, the knee extension and ankle plantar flexion were used. The cable tensiometer proved to be the most consistent of the four instruments tested. The results showed an objectivity coefficient between .90 and .96 in all tests. This was equal to or higher than the coefficients for the other instruments in all but two strength tests. It was reported that the strain gauge exceeded the tensiometer in objectivity coefficient for finger flexion with a score of .94 to .90 and the spring scale exceeded the tensiometer in the neck extension .97 compared to .92. The objectivity coefficients for the strain gauge were below .90 on three tests: .87 for the neck extension, .85 for the wrist dorsal flexion, and .81 for the knee extension strength test (7:398-411).

Because the myometer and the spring scale had limitations in the amount of pounds recorded, seventy and one-hundred pounds respectively, they could only be used for measuring the weak muscle movements. The spring scale was used in the neck extension and wrist dorsal flexion strength test and compared to the tensiometer on these two tests with objectivity coefficients of .91 and .97. The myometer recorded an objectivity coefficient of .82 for finger flexion and .79 for wrist dorsal flexion strength (7:398-411).

Clarke pointed out that consideration of the myometer as a testing device should be considered as it operates on a different principle than the other three reported instruments. It functions on the break device or isometric contraction as the other instruments operate on an isotonic contraction basis. Inter-instrument correlations between the tensiometer and the myometer were found to be .14 and .36 for finger flexion and wrist dorsal flexion, respectively. The spring scale objectivity coefficients were satisfactory (.91 and .97) but a serious fault was found in the movement of the instrument when the tension was applied. This allowed joint angles to move and the result was a change in the angle of pull (7:398-411).

The Wakim-Porter strain gauge showed a satisfactory degree of precision for measuring strength. The inter-instrument correlation showed low correlation between the tensiometer and the strain gauge on the four weak movement muscle tests ranging from .14 to .43. This could be due to the strain gauge being sensitive to change in room temperatures and the distortion of the aluminum ring used in the construction (11:15).

The use of the tensiometer as a strength testing device for elementary age youngsters was explored by Schopf and Clarke in an effort to reduce eighteen cable tension tests down to a fewer number in order to facilitate the administration of these tests in battery form to elementary school boys, ages nine through twelve, in grades four, five, and six (15:515-522).

Eighteen cable tension strength tests were chosen that would best represent the major muscle groups throughout the body. The eighteen tests were: elbow flexion and extension; shoulder flexion, extension, adduction and inward rotation; neck extension; trunk flexion and extension; hip flexion, extension, adduction, abduction, and inward rotation; knee flexion and extension; and ankle dorsal flexion and plantar flexion. The subjects used for the testing were 128 boys selected randomly from Medford, Oregon public schools. These boys attended school in the year 1956-57 and were assumed to be without organic or physical disabilities. Graduate and undergraduate students assisted in the testing. They were from the University of Oregon and Southern Oregon College. The testers obtained objectivity coefficients based on the test-retest method of .87 to .98. In order to select the minimum number of cable tension strength tests from the eighteen tests utilized, Clarke and Schopf used the mean of the eighteen strength tests as the criterion. The Wherry-Doolittle method for computing the multiple correlations was used in the final analysis for selecting the tests that would best represent the eighteen tests utilized for measuring strength. The tests that were selected based upon their high multiple correlation of .940--.976 were shoulder extension, ankle plantar flexion, trunk extension and knee extension (15:517-518).

These tests were described as follows:

Trunk Extension

Starting position--Subject in prone position; hips in 180 degree extension and adduction; knees fully extended; hands clasped behind back.

Attachments--Trunk strap around chest, close under arm pits; pulling assembly attached beneath subject through slit in table.

Precautions--Prevent lifting of hips by bracing (15:517).

Knee Extension

Starting position--Subject in sitting position, leaning backward, arms extended to rear, hands grasping sides of table; left knee (test side) in 115 degree extension.

Attachments--Regulation strap around leg midway between knee and ankle joints; pulling assembly attached to hook at lower end of table.

Precautions--Prevent lifting buttocks; prevent flexion of elbows (15:517).

Shoulder Extension

Starting Position--Subject in prone position, hips and knees flexed, feet resting comfortably on table; upper left arm (test side) adducted at shoulder to 190 degrees;

shoulder flexed to 90 degrees; elbow flexed with wrist in prone position.

Attachments--Regulation strap around humerus mid-way between shoulder and elbow joints; pulling assembly attached to wall beyond subject's head.

Precautions--Prevent shoulder elevation by bracing with hand; prevent humerus abduction by guiding elbow (15:518).

<u>Ankle</u> <u>Plantar</u> <u>Flexion</u>

Starting Position--Subject in prone position, hips in 180 degree extension and adduction, knees in 180 degree extension, arms folded on chest; left ankle (test side) in 90 degree flexion, mid-position of inversion and eversion.

Attachments--Regulation strap around foot above metatarsal-phalangeal joint; pulling assembly attached to wall at subject's head.

Precautions--Prevent inversion or eversion at ankle joint, extension of metatarsal-phalangeal joint, and raising leg; brace behind shoulders to stabilize subject (15: 518).

In 1958, Harrison established cable tension strength norms for boys seven, nine, twelve, and fifteen years of age and also established the normality of his distribution by applying tests for skewness and kurtosis for the following muscle groups: elbow flexion, shoulder flexors, shoulder inward rotators, trunk flexors, trunk extensors, hip flexors, hip extension, hip inward rotators, knee flexors, knee extensors, ankle dorsal flexors and ankle plantar flexors. Hull scale scores were then prepared and reported (20).

Stolsig, in a follow up study, reported the norms for boys eight, ten, thirteen and sixteen years of age, using the same subjects as Harrison--335 boys from the Medford public schools during the 1957-58 academic year. Stolsig reported the same twelve tests as Harrison, and Hull scale scores were prepared (41).

Seidler constructed norms for the upper elementary, junior high and senior high school boys. Seidler helped in giving twenty-five cable tension strength tests to twenty-four boys at each grade level from four through twelve. The minimum number of strength tests adequately representive of the skeletal musculature were then selected by means of factor analysis and multiple correlation procedures. Utilizing the studies of Gray and Bilik, Seidler chose the shoulder extension, knee extension, and ankle plantar flexion tests because of the high correlations reported. As an outcome of this study, cable tension strength test norms were established for upper elementary, junior, and senior high school students (38).

Clarke and Baily reported strength curves for fourteen joint movements in an attempt to determine the amount of force activated by muscles in a complete range of motion for the joints which they control. The results, as reported by Clarke and Baily, pointed out the following:

> . . . that other things being equal a muscle exerts its greatest power when it functions at its greatest tension; that the angle at which the muscle pulls is of importance but probably not as important as the tension; that the mechanical arrangements of the levers sometimes interfere with the full application of strength, even though the muscles may be at their greatest length; and that there probably is an optimal position in which each muscle group functions the best (11:51).

<u>Summary</u>

Since the introduction of the cable tensiometer in 1948, the device has enjoyed increasing use in measurement of isolated muscle groups. Studies have demonstrated consistent reliability, objectivity, and validity. Improvements in use have dealt with joint angles, body positions, and strap positions. A total of thirty-eight tests now exist for the cable tensiometer. Norms have been developed for various age and age-weight groups of males.

## II. ISOMETRIC AND ISOTONIC STRENGTH

Investigation has shown that no single method is adequate in achieving maximum development of both strength and endurance (31:79-87). The development of strength is a matter unique to the individual performer. However, the correlation between isometric and isotonic strength is felt to be relevant, according to Jokl:

> Under physiological conditions, contraction always involves an isometric and isotonic phase: Before a person can lift ten pounds isotonically, he must first build up a tension of ten pounds isometrically (26:64).

Much has been stated about the use of isometric exercises for the improvement of physical condition of individuals. Higdon pointed out that Hettinger and Mueller found in their first study, that use of isometric contractions produced strength gains of five per cent a week (22:58-59). H. Harrison Clarke, in referring to this same study, stated:

> No study has verified the strength gain of 5 per cent per week for ten weeks (50 per cent for the entire period) from a single six second daily contraction against resistance consisting of two-thirds of the muscle's strength, as reported by Hettinger and Mueller. Apparently, a more realistic, although perhaps still generous, figure is 2 per cent each week (14:165).

Royce reported that there have been many people in the profession questioning the amount of strength gained in a given time since the report of Hettinger and Mueller. Royce referred to a new study by Hettinger in which he reevaluated his original study of isometric strength training and reported only 3.3 and 1.8 per cent increase per week in strength gain. These studies were carried out in 1958 and 1961, respectively (36:215).

Jokl, in writing about isometric contraction, also refuted some of the claims of the effect of isometric contraction on strength. He stated:

> It is doubtful whether there is any justification for claims to the effect that a few seconds of isometric contractions per day suffice to maintain the normal trophic state of the musculature and even to bring about optimal muscular growth and function. The whole volume of empirical evidence supports the view that under normal circumstances isotonic resistance training is as effective in producing hyperthrophy as isometric exercise (26:64-70).

Higdon, quoting Bender, pointed out that isometrics have much to offer but that he [Bender] was concerned over the amount of charlatanism associated with isometrics, and that those in the medical profession may come to look upon isometrics as a fad. Bender pointed out that this is not entirely true and stated we need to accept isometrics but recognize its limitations (22:58-59).

Higdon also reported the opinions of Dr. D. W. Paul, University of Iowa, team physician. Dr. Paul discussed the need for both isometric and isotonic exercise and stated that boys who have trained only with isometrics will lose their strength faster than those who exercise isotonically. Dr. Paul said the reasons for this physical phenomena were not known at the present time by physiologists (22:58-59).

There have been many studies comparing the effectiveness of isometric training against isotonic training and most of them point out there is little difference in the two as far as building strength. Mathews and Kruse investigated the effects of isometric and isotonic exercises on elbow flexor muscle groups. Sixty college male students exercised for a four week period. The group was divided up into four groups; group I exercised twice a week, group II exercised three times a week, group III exercised four times a week and group IV exercised five times a week. It was found that the more frequent the exercise period, the greater the number of subjects who increased significantly in strength in both the isometric and isotonic units. Mathews and Kruse reported that it appeared that the isometric type exercising group made greater gains than the isotonic groups, however, not significantly so (30:26).

In still another investigation, Rasch attempted to determine the relationship between the tension which can be executed by conditioned subjects in a single maximum isometric elbow contraction and the maximum weight which can be moved in a single isotonic elbow flexion. Twenty-four male students were used; they trained for a period of six weeks using progressive unilateral curls and presses. Rasch found a difference of 1.4 pounds between the means for those trained isometrically (43.2 pounds) and the isotonic methods (41.8 pounds). The difference was not significant between a maximum isometric elbow contraction and the amount of weight which can be handled in a single maximum isotonic elbow flexion (35:85).

Chui investigated the effects of isometric and dynamic weight training exercises on strength and speed of execution of a single movement. He found little difference in the gain of strength or in the speed of movement between three groups using three different techniques of speed and strength building. All three groups reportedly showed significant increase in strength and an increase in speed of movement with resistance being applied and also with no resistance being applied (5:298).

McCraw and Burnham attempted to establish the effectiveness of three methods of resistive exercise in increasing muscular strength and endurance. They compared the isotonic and isometric methods and a speed technique in which the muscles were contracted quite rapidly using light weights. The investigators were concerned with strength and endurance of the extensor muscles of the leg and the extensor muscles of the forearm as well as the flexor muscles of the upper arm. The investigation was performed with 93 freshmen and sophomore males enrolled in required physical education at the University of Texas. The subjects were divided into three groups: group I using the isotonic exercise, group II using the isometric exercise, and group III using the speed exercise. McCraw and Burnham, using the multiple linear regression technique for variance found these results: The arm strength--there was no significant difference among the three groups. They did say there seemed to be a slight advantage to the isometric method, particularly for individuals with high initial scores. Leg strength--the researchers pointed out that it seemed the isotonic and isometric method appears to be best for developing leg strength for those subjects having considerable initial strength. Arm endurance--it was found that the speed exercises were better than the isometric program and for those subjects having better endurance at the outset, the isotonic method was superior to the isometric technique. Leg endurance was shown to be greatest by the speed exercising group. It was generally concluded by McCraw and Burnham that no single method was adequate in achieving maximum development in both strength and endurance. It was also pointed out that the beginning status of the individual may determine the effectiveness of the method used. They further concluded that strength may be developed by anyone of three methods but isometric and isotonic methods seem to be best for the person who is strong initially. They also pointed out as a result of this study, that muscle endurance can be developed best by rapid contractions of the muscle against a reasonably heavy load (31:79-97).

Berger investigated fifty-seven college males trained statically (isometrically) three times weekly for a period of twelve weeks as compared to 177 college men trained the same length of time with dynamic (isotonic) training programs that varied in time and repetitions. He found the group that trained dynamically gained significantly over the static group. Berger stated one of the advantages of static training was that a person can work out for five or six days a week for an extended length of time without great fatigue. A person training with weights would find this type of training difficult (3:131-135).

Logan, Lockhart, and Mott found in their investigation of different angles for isometric contractions, that the greatest gains seemed to occur in the range of motion when nearing complete flexion than at the other end of complete extension (28:858).

The arguments are great and varied to the extent that isometric and isotonic exercises produce strength. However, all investigators did agree on the importance of strength. It has been proven almost beyond doubt that both isometric and isotonic exercises practiced in various methods do develop strength. Clarke stated:

> Both isometric and isotonic forms of exercise improve muscular strength. However, the evidence shows little if any difference in the effectiveness of the two forms in achieving strength increase; the same result was obtained for different systems of progressive resistance exercise. Considerable variation in individual strength improvement exists for both forms of exercise (14:165).

Investigations point out that the relationship between muscle strength and hypertrophy are somewhat controversial. Davis, Logan, and McKinney indicated in their study that isotonic exercise produced hypertrophy in proportion to strength developed, whereas isometric exercise produced strength in excess of hypertrophy (16:54).

Summary

With the above studies in mind, and after reviewing the statements that have been made by those in the field, one can conclude by saying that each type of exercise seems to have its own advantages and disadvantages. One should use these techniques for building strength but should examine which one will best fit particular needs and objectives.

## III. ROGERS' STRENGTH INDEX

One of the most used and most often referred to strength tests is the physical fitness test battery prepared by Dr. Frederick Rand Rogers. He prepared the standardized test procedures and developed norms for its interpretation in 1925. This work was a milestone in the measurement of physical condition and muscular strength. This process of measurement was first started by Dudley A. Sargent, M.D., in 1880 (6:154-155).

Rogers' strength index scores are derived from seven tests which include: lung capacity, which is measured with a spirometer; grip strength, as measured with a manuometer or hand dynamometer; the back and leg lift which is measured with a dynamometer; and the pull-up test for boys and girls. The pull-up test for boys and girls differs in that boys perform on a chinning bar and girls use a lowered horizontal bar and pull-up from a slanted position. The final part of the test is the push-up performed by the girls on a bench thirteen inches high and twenty inches long. The boys perform dips on a parallel bar. The physical fitness index may be calculated by comparing the achieved strength index with a norm based upon sex, age, and body weight. The average physical fitness score is 100. This score may be considered as a measure of general physical condition to the extent that physical strength reflects that condition (6:155).

The use of this strength test battery was limited inasmuch as the equipment needed to give the test was expensive and the amount of time required to test a student was excessive (6:155). Because Rogers' test was limited in use, Clarke and Carter endeavored to simplify the test by reducing the number of test items so that it could be used by more educators in the field. They conducted a study of 356 boys in the Medford, Oregon public schools. The study included upper elementary, junior high, and senior high school boys, ages seven through seventeen years. They reinvestigated the anthropometric measures upon which the norms for the strength index were based. Rogers used only age, height and weight in the original study. The researchers used six anthropometric measures in this study. They included: sitting height, leg length, flexed-tensed upper arm girth, chest girth, calf girth, and hip width (13:3-10).

Multiple correlations obtained between the strength index and the two highest correlating variables were reported: standing height and flexed-tensed upper arm girth had a correlation of .59 for the upper elementary group; sitting height and flexed-tensed upper arm girth had a correlation of .79 for the junior high group; tensed-flexed upper arm girth and sitting height had a correlation of .68 for the senior high group. These correlations were all low, so they were considered of little value as a basis for norming the strength index. As a result of this investigation, the affinity of age, height, and weight to the strength index was researched for the ages nine through seventeen years. The multiple correlation was .901 between the strength index and weight and age. It appeared that the addition of height to the formula did not increase the correlation. This correlation was only .043 points higher than those of Rogers' whose correlation was .858. The decision to continue the use of weight and age as the basis for determining strength index norms was based on these comparative correlations (13:3-10).

The actual battery chosen for the simplification of Rogers' test were those tests that had a high correlation with either the strength index or the physical fitness index. As a result of the high correlation with the strength index, the following tests were recommended: upper elementary had a correlation of .977 for the leg lift, back lift, and push-ups; junior high and high school had two recommended tests depending on the amount of accuracy the tester wished to obtain from the results. Junior high formula "A" had a correlation of .987 for the leg lift and arm strength; junior high formula "B" had a correlation of .998 for the leg lift, arm strength, and right grip; senior high formula "A" had a correlation of .985 for the leg lift and arm strength; senior high formula "B" had a correlation of .996 for the leg lift, arm strength and back lift (13: 3-10).

## Summary

As a result of these high correlations with the strength index, the Oregon Simplification of the Rogers' Physical Fitness Test was developed. The dynamometer is the only piece of strength test equipment necessary to purchase. This equipment facilitates the use of the test at all age levels. The Oregon P.F.I. test was chosen for this study.

## IV. THE EXER-GENIE

A new conditioning exerciser being utilized by physical educators is the Exer-Genie. The Exer-Genie device makes possible a combination of both isometric and isotonic exercises for muscular strength development.

The Exer-Genie is approximately eight inches long and two inches in diameter. This instrument has an aluminum cylinder encased in a metal container. A nylon rope is turned around the cylinder in order to create resistance for the user to pull against. The selection of the resistance is accomplished by twisting the outside case and selecting the amount of resistance desired from the calibration chart that appears on the outside of the instrument.

The basic idea of the Exer-Genie is to tire a muscle and, without allowing that muscle to relax, move with selected resistance through a complete range of motion. Resistance may be selected from 0 pounds of resistance to 400 pounds of resistance.

The Exer-Genie was developed in the early 1960's and has been used by many school, college, and professional football and baseball teams. The Exer-Genie is manufactured by Exer-Genie, Inc., Fullerton, California.

Because the Exer-Genie is a new training device, the possibility of securing related research is limited. Studies that have been utilized with the United States Navy and with Lockheed Space and Missile Corporation could not be obtained.

Sterling and Nicolson compared weight training and Exer-Genie methods as a strength developer of the flexor and extensor muscles of the right forearm. They used thirty seventh grade boys working three times a week in their physical education classes for a period of six weeks. The subjects in the weight training group, under the direction of the teacher, selected the amount of weight they would use in the exercises (40:1-4).

The triceps extension and arm curl were the exercises selected. The weight lifters used four sets of seven repetitions while the Exer-Genie group used the same movements as the weight training group. The Exer-Genie group worked in pairs and the partner would hold the nylon cord from moving for the isometric phase of the exercise, the cord was released after a count of ten and the isotonic phase of the exercise was completed. Each subject in the group completed two sets of two repetitions. An analysis of the flexor muscle test data showed that both groups improved at the .01 level of significance with the Exer-Genie group superior at the .05 level of significance. The extensor muscle test found both groups improved in strength at the .01 level of significance (40:1-4).

Another test using the Exer-Genie as an exerciser was reported by Alexander, Martin, and Metz at the University of Minnesota. They used a karate class to compare the changes in body girth and skinfold measurements, muscular strength and endurance and cardiovascular fitness, for participants in a program continued for four weeks. The subjects were divided into two groups by random selection. One group used the Exer-Genie in a prescribed program of resistive movement twenty minutes, three times a week for a period of four weeks. The control group participated in the karate class as their only exercise. The researchers found significant improvements on the Balke-Ware Treadmill Test, Rogers' P.F.I., all girth measurements, and the chest skinfold measurements for the experimental group. The control group did not show any significant changes in measurement for any of the prescribed evaluations. The authors concluded by stating:

> Within the limitations of the study, training of this kind will have the following effects on physically conditioned young males: significant improvement in muscle development by reason of a reduction in skinfold measurement and an increase in body girth measurement; significant gains in strength and endurance as measured by the physical fitness index; small cardiovascular gains as measured by the Balke-Ware Treadmill Test (2:16-24).

Sarbo conducted a study to compare the results of isometric and isotonic exercise upon strength development of abdominal and elbow extensor musculature of college women.

The effects of the exercise upon girth and skinfold measurement were also examined (37:2).

Sarbo's investigation utilized three groups of college women totaling sixty-four freshmen, sophomore, and juniors. Group I was the isometric group and performed three ten-second maximum contractions with five seconds between each contraction once a day, five days per week, for trunk flexion and elbow extension. An adjustable metal gym bar was used for resistance. Group II was the isotonic group. This group performed maximum repetition abdominal curl-ups for thirty seconds and alternated extension of the right and left elbows for one minute using the Exer-Genie for applied resistance once a day, five days per week. Group III was the control group and participated in the pre- and post tests, along with their conventional physical fitness classes. Results of the seven week study showed that both group I and group II increased significantly in abdominal strength over group III. Group II increased significantly in left upper arm girth. While both the isotonic and isometric groups increased significantly over the control group, the conclusions reached by the study showed that isometric exercise was more effective than isotonic exercise for increasing abdominal strength of college women (37:95-96).

Sarbo reported the study of Lewis in which he compared traditional basketball conditioning drills and exercises using the Exer-Genie. Male college students trained three times per week for twelve weeks. The Exer-Genie group exercised for ten minutes at a session. He reported the Exer-Genie group to be superior although both groups showed statistically significant gains (37).

Alexander used the Exer-Genie in an attempt to increase the condition of his basketball team. He pretested twelve boys in the vertical jump, dips, and pull-ups and after six weeks of training, a post-test was given. The average increase for the vertical jump was 1.33 inches, increase in the pull-ups was 2.75 and an increase in dips of 3.25 was obtained (1:30).

McKinney, Logan and Birmingham investigated the possibility of keeping a baseball pitcher's arm in condition to throw hard during the off season. The investigators took a four man high school pitching staff and placed them in a seven week program after they had completed a season of working in forty games. Their average throwing velocity was 87.53 mph. Their work consisted of pulling the Exer-Genie through a normal throwing range of motion fifty times per day, five days per week. The Exer-Genie was set at two and one-half pounds of tension. The players were to throw fifty pitches through a string strike zone and jog one mile. This workout was considerably less than what the pitchers had done during the season. The researchers found a post-test velocity of 83.70 mph. An accuracy record was kept on 7,000 pitches which indicated a slight improvement in accuracy (32:58).

Sarbo reported a study done by Rhode using the Exer-Genie to investigate the effects of isometric-isotonic contractions on elbow extension and wrist flexion, extension, abduction and adduction. Twenty baseball athletes exercising five times per week for four weeks were used as subjects. Group I utilized elbow exercises consisting of two sets of five maximum resistance pulls through a complete range of motion with two six second maximum isometric contractions (at the 45 and 135 degree angles) and wrist exercises consisting of swinging a bat attached to the Exer-Genie. Group II performed the same elbow and wrist exercises as group I, consisting of isometric-isotonic contractions with the Exer-Genie. Group III was the control group who participated in only the pre and post tests (37).

Significant strength gains were recorded by group I in wrist adduction, however group I showed significantly different results than group II and group III in wrist extension. The greatest number of significant strength increases was shown by group II which had significant increase in elbow extension over groups I and III; in wrist flexion, group II increased significantly over group I; and in wrist extension, abduction, and adduction, group II increased significantly over group III. Significant strength gain was shown by group III in wrist flexion and a significant loss in wrist extension. It was concluded by Rhode from this study, that the specific exercise method was superior to the isometric-isotonic method involving the skill of increasing muscle strength (37).

Logan, McKinney and Rowe studied thirty-nine college baseball players to determine the effects of specific isometric-isotonic exercises, using the Exer-Genie, on the velocity of a baseball thrown in an overhand motion. With three groups training six weeks in three different techniques they found the .05 level of significance was reached by the Exer-Genie group matched with group II who performed by throwing thirty times per day, five days a week and group III who only took the pre and post test (29:55-58).

Sarbo also reported a study by Helmkap in which she compared the effects of Exer-Genie training and softball throw paractice on the AAHPER Softball Throw for Distance Test with tenth grade girls. She was reported as not finding any significant difference between the two training methods (37).

## Summary

The Exer-Genie as a physical conditioning device was utilized for purposes of this study because of the isotonic-isometric technique offered and because of its ease of use in physical education.

# CHAPTER III

## METHODS AND PROCEDURES

This Chapter consists of: (1) identification of the sub-fit boys; (2) program organization for experimental groups A and B and control group C; (3) reliability of the tester; and (4) statistical treatment of the data.

### I. IDENTIFICATION OF SUB-FIT BOYS

The writer had the cooperation of the Broadfront personnel of Ellensburg, Washington public schools, and the Kittitas, Washington School District in the selection of the subjects for this investigation. All boys in the fourth, fifth, and sixth grades were administered the Oregon Simplification of the Rogers' Physical Fitness Test to determine their general physical condition. Those scoring ninety and below were given the P.F.I. again, in order to be certain of the accuracy of the original score. All boys scoring ninety and below on the re-test were considered to have a low P.F.I. and were placed in experimental groups A and B at Ellensburg, and control group C at Kittitas.

Experimental group A participants used the Exer-Genie. Seventeen boys comprised this group.

The subjects who were in the Ellensburg Broadfront developmental physical education program under the direction of the Broadfront personnel, become experimental group B which participated in a traditional method of physical education. There were fifteen boys participating in this program. The control group C from Kittitas numbered fourteen boys and participated in a regular elementary school physical education program under the direction of classroom teachers.

Clarke and Schopf's cable-tension test battery was used to test for particular muscle group weaknesses of all boys in the experimental groups A and B at Ellensburg. (See Figures 10-13 in the Appendix.) With the completion of the cable-tension strength tests, the scores of experimental group A were compared to the norms prepared by Harrison (20) and Stolsig (41) to determine the magnitude of individual muscle group weaknesses. Because there were no norms available for the shoulder extension tensiometer test, the arm strength test scores of the P.F.I. test were compared to the arm strength test scores computed by Dr. Robert N. Irving (24) from a study done in the San Juan Unified School District at Sacramento, California on a group of boys of comparable ages known to be in good physical condition. After the results of the cable tension tests were compared, the writer prescribed specific Exer-Genie exercises for group A on the basis of diagnosed weaknesses as shown by the tensiometer strength tests and the P.F.I. arm strength test.

## II. DESCRIPTION AND PROCEDURES OF THE PROGRAM

### Exer-Genie Physical Education--Experimental Group A

The experimental group A used the Exer-Genie in a circuit training technique consisting of six stations: the big four using the curl technique, the clean technique, two man rowing, forward bend, standing bench press, and jogging 440 yards. These exercises were repeated three times each by every subject except for the jogging which was done by each subject during class period. A detailed description and pictures of these exercises appear in Appendix A.

In addition to the circuit training method used, each subject was given a special exercise to use on the Exer-Genie. The choice of special exercise was dependent upon the diagnosis of the subject's greatest muscular weakness as shown by his $T_1$ cable-tension strength test.

For weakness of the shoulder muscles, the bench press and the latissimus pull were prescribed. This was accomplished by having the subject stand, facing the wall with arms fully extended at shoulder height, grasping the handle of the Exer-Genie and pulling down to the thighs. Keeping the arms straight and elbows locked, the pulling was started after an isometric contraction of approximately ten seconds.

For weakness of the back, the subjects performed the rowing exercise.

The weakness of the legs was countered by prescribing the football kick and the bicycle exercises. The football kick was done by attaching the Exer-Genie to a hook approximately two inches off the floor. The subject stood with his back to the wall and the leg flexed at a ninety degree angle. The foot was placed in the stirrup handles of the Exer-Genie and after a contraction of ten seconds, the leg was moved through a range of motion that ended up with a complete extension of the leg. The bicycle exercise was done by the subject sitting in a metal chair with his back to the wall and his feet placed in the stirrup handles of the Exer-Genie with the machine attached to the wall approximately four feet high. The subject held resistance with each leg for an isometric contraction of ten seconds, and then proceeded through a bicycle motion with the legs. This was done for five repetitions for each leg.

The experimental Exer-Genie group A worked for a period of thirty minutes a day, three times a week, for a period of ten weeks. In addition to a thirty minute regular elementary school physical education program, the total time spent by these students in physical education, was 2,400 minutes for the ten week period.

<u>Traditional Physical Education--Experimental Group B</u>

Because a developmental physical education program had been in existence in Ellensburg since 1967, it was designated as being a traditional program. This developmental program was organized utilizing the circuit training technique. The subjects progressed through the circuit for a period of thirty minutes each class period.

The circuit consisted of eight stations which included: (1) weight lifting, using the military press; (2) overhead ladder; (3) climbing fence; (4) climbing through a twelve foot tunnel; (5) hand walking a five foot low parallel bar; (6) walking a balance beam; (7) weight lifting, using the arm curl technique; and (8) jogging 440 yards. The weight lifting equipment consisted of number 10 cans filled with cement rather than bar bells. (See Appendix B.)

Total time spent in the regular physical education class--which included individual and team activities and rhythms--as well as the above developmental physical education program, totaled 2,400 minutes for the ten week period.

<u>Regular Physical Education Program--Control Group C</u>

The fourteen participants in the control group spent fifteen minutes during each class period on calisthenics. Their program also included the following activities: touch football, tumbling, and basketball. The control group had a total of 2,250 minutes of physical education class time for a ten week period.

III. RELIABILITY OF THE TESTER

The objectivity of the researcher in conducting the tensiometer strength tests was established after practice with subjects from the Central Washington State College girl's field hockey team and subjects from the elementary schools of Ellensburg, Washington. A product-moment coefficient of correlation was computed between Dr. Robert N. Irving, Department of Physical Education, Central Washington State College, and the researcher. Garrett's formula for computation was used for this purpose:

$$r = \frac{N\Sigma XY - \Sigma X \cdot \Sigma Y}{\sqrt{[N\Sigma X^2 - (\Sigma X)^2][N\Sigma Y^2 - (\Sigma Y)^2]}}$$

The first correlation was carried out utilizing twenty-eight subjects. These correlations were: trunk extension .867; knee extension .880; shoulder extension .853; and ankle plantar flexion .844.

The (N) was small, and the correlations were not as high as Clarke had recommended:

> As .90 is the accepted standard indicating desirable objectivity and as tests with coefficients as low as .80 may be used for individual measurement, none of the 28 tests studied should be considered sufficiently unsatisfactory to warrant elimination from the battery (15).

After increasing the (N) to forty-two participants, the correlation increased in all tests with the following results: trunk extension .883; knee extension .888; shoulder extension .860; and ankle plantar flexion .893. These correlations were considered to be sufficiently satisfactory as stipulated by Clarke, as it appeared that upon the adding of more cases, four sufficiently high objectivity coefficients would finally emerge. The researcher, therefore, proceeded with the tensiometer strength testing.

## IV. STATISTICAL TREATMENT OF THE DATA

In order to evaluate statistically the change in P.F.I. scores within the traditional, Exer-Genie, and control groups, their respective $T_1$ tests were compared to their own $T_2$ tests by means of the $\underline{t}$ ratio applied to correlated groups, using a one-tailed test.

The comparison of significance of increase in P.F.I. means between the Exer-Genie, traditional, and control groups was first attempted by use of the analysis of variance. Upon close scrutiny, it was found that the variance of the control group was too great in comparison to the variances of the two experimental groups. This lack of minimal homoscedasticity was verified by the use of Hartley's maximum F-ratio test as described by Bruning and Kintz (4). Therefore, it was necessary to apply a non-parametric test, that of Kruskal and Wallis, the one-way analysis of variance by ranks, described by Siegel (39). This test makes no assumptions about the data being analyzed.

The changes in the four cable-tension strength scores for the Exer-Genie and the traditional groups were statistically analyzed by comparing their $T_1$ test scores to their own $T_2$ test scores by use of the *t* ratio applied to correlated groups using a one-tailed test.

The Exer-Genie and traditional groups' four cable-tension strength test scores were individually compared by using a one-tailed *t* ratio test for significance of difference between means of uncorrelated groups. The $T_1$ scores were compared between groups to determine if the groups were from the same population. The $T_2$ scores were then compared for significance of change.

The four cable tension tests were summed for each subject in the Exer-Genie and traditional groups. The achieved score was then divided by the norm for the sum of these four tests, as prepared by Schopf (15). The basis for Schopf's norms was sex, age in half-years, and body weight in pounds. The index or battery scores thus derived could be interpreted in a manner comparable to the Rogers' P.F.I. battery inasmuch as the statistical methods of preparation were purposely identical. The comparison of the cable tension battery scores of the Exer-Genie group with those of the traditional group was done by use of the Kruskal-Wallis one-way analysis of variance by ranks.

The changes in cable-tension strength battery scores for the Exer-Genie and the traditional groups were statistically analyzed by comparing their $T_1$ index or battery scores to their own $T_2$ scores by use of the *t* ratio applied to correlated groups.

CHAPTER IV

# ANALYSIS OF THE DATA

The first purpose of this study was to compare a group of pupils who had used the Exer-Genie exclusively in developmental physical education with a group of pupils who had utilized other more traditional means of developing the skeletal muscles, and each of these with a control group utilizing typical elementary school physical education activities. These three programs were described earlier. The statistical comparisons were based upon $T_1$ and $T_2$ scores.

Secondly, it was the purpose of this study to compare the development of specific muscular strengths in a program using the Exer-Genie with the development of the same specific muscular strengths in a traditional developmental program.

The Exer-Genie group started with nineteen participants (N=19) for the $T_1$ P.F.I. test. One subject was not present for three weeks during the study, due to illness; therefore his scores were eliminated from the investigation. After several observations of the Exer-Genie group, the writer decided it was necessary to eliminate another subject from the investigation. This boy had difficulty in following directions of the instructor, and it was very hard to communicate with him. Upon further investigation, the writer discovered that this boy was a member of a special education class. For these reasons, he was not included in the study. The final number of participants for the Exer-Genie group was seventeen.

Because this study was concerned only with positive changes resulting from training, the one-tailed _t_ ratio test was used to test the significance of changes.

## I. COMPARISONS OF THE EXER-GENIE GROUP, TRADITIONAL GROUP, AND CONTROL GROUP P.F.I. TEST RESULTS

In order to analyze the P.F.I. changes within groups, the mean $T_1$ scores of each group were compared to their own $T_2$ means. Data analyses were made by means of the _t_ ratio test for the significance of the difference between means of correlated groups, as specified by Garrett. The _t_ statistic is the ratio of the difference between means divided by their combined standard errors, and for correlated groups, is stated by Garrett as follows, in the case of the computation of the standard error of the difference (18:226-228):

$$SE_D = \sqrt{\sigma_{m1}^2 + \sigma_{m2}^2 - 2r_{12}\sigma_{m1}\sigma_{m2}}$$

Experimental Group A - Exer-Genie (N=17)

The mean for $T_1$ was 79.8, and the mean for $T_2$ was 97.2. The correlation between the pre-test and the post-test was .448. The difference between the mean scores was a gain of 17.4 points. This gave a *t* ratio of 7.67 which was significant well beyond the .01 level of confidence.

Experimental Group B - Traditional (N=15)

The mean for $T_1$ was 80.8, and the mean for $T_2$ was 108.1. The correlation between the initial test and the final test was .504. The difference between the mean scores was a gain of 27.3 points. This gave a *t* ratio of 11.38 which was significant well beyond the .01 level of confidence.

Control Group C - (N=14)

The mean for $T_1$ was 74.3, and the mean for $T_2$ was 91.3. The correlation between the initial test and final test was .606. The difference between the mean scores was a gain of 17.0 points. This gave a *t* ratio of 4.78 which was significant well beyond the .01 level of confidence.

All groups improved beyond the .01 level of confidence as indicated by their P.F.I. scores from the time of $T_1$ to the time of $T_2$. Table I summarizes the preceding facts.

TABLE I

AMOUNT AND SIGNIFICANCE OF CHANGE IN P.F.I. SCORES: INTRA-GROUP COMPARISONS

| GROUP | $M_1$ | $M_2$ | r | Diff | $SE_D$ | df | t |
|---|---|---|---|---|---|---|---|
| Exer-Genie | 79.8 | 97.2 | .448 | 17.4 | 2.27 | 32 | 7.67* |
| Traditional | 80.8 | 108.1 | .504 | 27.3 | 2.4 | 28 | 11.38* |
| Control | 74.3 | 91.3 | .606 | 17.0 | 3.56 | 26 | 4.78* |

*Significant well beyond the .01 level of confidence

Inter-Group Comparisons

Using the Kruskal-Wallis H Test for one-way analysis of variance, the R value representing the summation of ranks for each of the exercise categories was determined by ranking the scores consecutively from the lowest to the highest and then summating within categories. The procedure is carefully explained by Siegel (39). It was determined that the experimental group B had the highest R value with a score of 447.5. The Exer-Genie group had the second highest R value with a score of 351.0. The control group had the lowest R value with a score of 278.5.

A chi square value was determined from the H score which was computed to be 4.13. This value did not reach the .05 level of significance for the traditional group. Table II summarizes these facts as indicated by the P.F.I. scores.

TABLE II

KRUSKAL-WALLIS ONE-WAY ANALYSIS OF VARIANCE BY RANKS
INTER-GROUP COMPARISONS

| EXER-GENIE | | | | TRADITIONAL | | | | CONTROL | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| $T_1$ | diff | $T_2$ | rank | $T_1$ | diff | $T_2$ | rank | $T_1$ | diff | $T_2$ | rank |
| 89 | -5 | 84 | 2.0 | 77 | 14 | 91 | 16.0 | 90 | -9 | 81 | 1.0 |
| 67 | 0 | 86 | 5.0 | 79 | 14 | 93 | 16.0 | 78 | -2 | 76 | 3.0 |
| 86 | 0 | 86 | 5.0 | 79 | 17 | 95 | 20.0 | 63 | 7 | 70 | 8.0 |
| 81 | 0 | 81 | 5.0 | 83 | 19 | 102 | 21.0 | 71 | 9 | 80 | 11.0 |
| 78 | 6 | 84 | 6.0 | 80 | 24 | 104 | 25.5 | 67 | 13 | 80 | 13.5 |
| 77 | 7 | 84 | 8.0 | 76 | 26 | 102 | 28.5 | 89 | 13 | 102 | 13.5 |
| 77 | 7 | 84 | 8.0 | 73 | 26 | 99 | 28.5 | 76 | 14 | 90 | 16.0 |
| 73 | 11 | 84 | 12.0 | 84 | 26 | 110 | 28.5 | 90 | 20 | 110 | 22.0 |
| 79 | 15 | 94 | 18.0 | 90 | 27 | 117 | 31.0 | 50 | 21 | 71 | 23.5 |
| 88 | 16 | 104 | 19.0 | 90 | 28 | 118 | 32.5 | 77 | 24 | 101 | 25.5 |
| 70 | 21 | 91 | 23.5 | 82 | 31 | 113 | 34.0 | 55 | 26 | 81 | 28.5 |
| 80 | 28 | 108 | 32.5 | 85 | 32 | 117 | 36.0 | 74 | 32 | 106 | 36.0 |
| 84 | 33 | 117 | 38.0 | 79 | 40 | 119 | 42.0 | 86 | 32 | 118 | 36.0 |
| 82 | 36 | 118 | 39.0 | 75 | 41 | 116 | 43.0 | 74 | 38 | 112 | 41.0 |
| 81 | 37 | 118 | 40.0 | 81 | 44 | 125 | 45.0 | | | | |
| 75 | 43 | 118 | 44.0 | | | | | | | | |
| 82 | 49 | 131 | 46.0 | | | | | | | | |
| | | | R=351 | | | | R=447.5 | | | | R=278.5 |

$$H = \frac{12}{N(N+1)} \sum \frac{R^2}{n} - 3(N+1)$$

$$= \frac{12}{46(47)} \left[ \frac{(351)^2}{17} + \frac{(447.5)^2}{15} + \frac{(278.5)^2}{14} \right] - 3(47)$$

$$\doteq 145.13 - 141 = \chi^2 4.13 \quad \chi^2 = > .20 < .10$$

Within each section the $T_1$ scores appear in the first column and the $T_2$ scores appear in the third column. The difference between scores appears in the second column while the consecutive rankings between groups appear in the last column. The summation of the rankings appears as the R values in each section. The H value is 4.13.

Summary

While $T_1$ and $T_2$ test results showed significant gains in P.F.I. within each group, no one group showed significant gain over another. The traditional experimental group B showed the highest P.F.I. improvement, with the Exer-Genie the second highest. The control group showed the least improvement.

## II. COMPARISONS OF MEAN SCORES OF THE EXER-GENIE GROUP AND TRADITIONAL GROUP, CABLE TENSIOMETER STRENGTH TESTS

A comparison was made of four specific muscular strengths as recorded by the cable tensiometer in order to analyze the mean gains made by the Exer-Genie group and the traditional group. The tensiometer units were converted to pounds by the use of the conversion chart inside the tensiometer case. Three types of comparisons appear in this section, as follows: (1) significance of difference between $T_1$ and $T_2$ means for each experimental group--intra-group comparisons; (2) significance of difference between $T_1$ means of each group--inter-group comparisons; and (3) significance of difference between $T_2$ means of each group--inter-group comparisons.

Intra-Group Comparisons--Experimental Group A - Exer-Genie (N=17)

Raw score $T_1$ means of the Exer-Genie group A and the traditional group B were each compared to their own $T_2$ means by the *t* ratio test for significance of difference between correlated means.

Trunk extension. The $T_1$ test mean score was 55.2 pounds. The $T_2$ test mean score was 69.9 pounds. The correlation between the initial test and the final test was .255. The difference between the mean scores was a gain of 14.7 pounds. This gave a *t* ratio of 2.35 which was statistically significant at the .05 level.

Knee extension. The $T_1$ mean score was 88.8 pounds. The $T_2$ test mean score was 109.5 pounds. The correlation between the initial test and the final test was .821. The difference between the mean scores was a gain of 20.7 pounds. This gave a *t* ratio of 5.75 which was statistically significant well beyond the .01 level of confidence.

Shoulder extension. The $T_1$ test mean score was 51.2 pounds. The $T_2$ test mean score was 67.9 pounds. The correlation between the initial test and the final test was .604. The difference between the mean scores was a gain of 16.7 pounds which gave a *t* ratio of 5.59. This was statistically significant well beyond the .01 level of confidence.

Ankle plantar flexion. The $T_1$ test mean score was 101.4 pounds. The $T_2$ test mean score was 121.3 pounds. The correlation between the initial test and the final test was .821. The difference between the mean scores was a gain of

19.9 pounds which gave a t ratio of 2.89. This was statistically significant beyond the .01 level of confidence.

The Exer-Genie group showed improvement at the .05 level or beyond in all areas of the cable tension test battery. Table III depicts these results.

TABLE III

AMOUNT AND SIGNIFICANCE OF CHANGE IN FOUR CABLE TENSION TESTS: EXER-GENIE GROUP

| TEST | $M_1$ | $M_2$ | r | diff | $SE_D$ | df | t |
|---|---|---|---|---|---|---|---|
| Trunk Extension | 55.2 | 69.9 | .255 | 14.7 | 6.26 | 32 | 2.35 |
| Knee Extension | 88.8 | 109.5 | .821 | 20.7 | 3.60 | 32 | 5.75 |
| Shoulder Extension | 51.2 | 67.9 | .604 | 16.7 | 2.99 | 32 | 5.59 |
| Ankle Plantar Flexion | 101.4 | 121.3 | .821 | 19.9 | 6.88 | 32 | 2.89 |

Note: For 32 df the t ratio must be *2.450 and 1.694 to be significant at the .01 and the .05 levels of confidence respectively, for one-tailed tests.
* by interpolation (4:219).

Intra-Group Comparisons--Experimental Group B - Traditional (N=15)

Trunk extension. The $T_1$ test mean score was 57.6 pounds. The $T_2$ test mean score was 59.7 pounds. The correlation between the initial test and final test was .482. The difference between the mean scores was a gain of 2.1.

This gave a *t* ratio of .384 which was not statistically significant.

*Knee extension*. The $T_1$ test mean score was 95.0 pounds. The $T_2$ test mean score was 106.1 pounds. The correlation between the initial test and final test was .812. The difference between the mean score was a gain of 11.1 pounds. This gave a *t* ratio of 3.43 which was significant beyond the .01 level.

*Shoulder extension*. The $T_1$ test mean score was 56.2 pounds and the $T_2$ mean was 62.5 pounds. The correlation between the initial test and final test was .650. The difference between the mean scores was a gain of 6.3. This gave a *t* ratio of 2. 29 which was significant at the .05 level.

*Ankle plantar flexion*. The $T_1$ mean test was 106.1 pounds. The $T_2$ mean test was 103.5 pounds. The correlation between the initial test and final test was .811. The difference between the mean scores was a loss of 2.6 pounds.

The improvement by the traditional group of only 2.1 pounds in trunk extension was not sufficient to be considered significant. In addition to this, a regression was found in ankle plantar flexion strength from $T_1$ to $T_2$. The amount of improvement in the knee extension test was enough to be significant at the .01 level of confidence and the amount of improvement in shoulder extension strength was significant at the .05 level of confidence. Table IV contains these figures.

TABLE IV

AMOUNT AND SIGNIFICANCE OF CHANGE IN FOUR CABLE TENSION TESTS: TRADITIONAL GROUP

| TEST | $M_1$ | $M_2$ | r | diff | $SE_D$ | df | *t* |
|---|---|---|---|---|---|---|---|
| Trunk Extension | 57.6 | 59.7 | .482 | 2.1 | 5.46 | 28 | .384 |
| Knee Extension | 95.0 | 106.1 | .812 | 11.1 | 3.24 | 28 | 3.43 |
| Shoulder Extension | 56.2 | 62.5 | .650 | 6.3 | 2.75 | 28 | 2.29 |
| Ankle Plantar Flexion | 106.1 | 103.5 | .811 | 2.6 | 4.19 | 28 | ** |

Note: For 28 df the *t* ratio must be 2.467 and 1.701 to be significant at the .01 and .05 levels of confidence respectively, for one-tailed tests.
** Ankle plantar flexion strength decreased from $T_1$ to $T_2$.

Inter-Group Comparisons

The $T_1$ raw score means for each of the experimental groups for each of the four cable tension tests was analyzed for significance of difference by use of the *t* ratio for uncorrelated groups. As shown by Table V, located on page 64, in none of the tests were the differences between the experimental groups large enough to be statistically significant. With this established, the study was continued for the ten-week period. At this time, the $T_2$ mean scores for each group were statistically analyzed for significance of difference between the two groups, with the following results.

Trunk extension. The $T_2$ mean score for the Exer-Genie group was 69.9 while the $T_2$ mean score for the traditional group was 59.7. The difference between means was 10.2 pounds. The *t* score was 1.32 which was not statistically significant.

Knee extension. The $T_2$ mean score for the Exer-Genie group was 109.5 while the mean score of the traditional group was 106.1. The difference between means was 3.4 pounds. The *t* ratio was .41 which was not statistically significant.

Shoulder extension. The $T_2$ mean score for the Exer-Genie group was 67.9 while the mean score of the traditional group was 62.5 pounds. The difference between means was 5.4. The *t* ratio was 1.04 which was not statistically significant.

Ankle plantar flexion. The $T_2$ mean score for the Exer-Genie group was 121.3 while the mean score of the traditional group was 103.5. The difference between means was 17.8. The *t* ratio was 1.68 which was not statistically significant.

It would appear that neither group was statistically significant over the other as measured by the cable tensiometer raw score results, and analyzed by the *t* ratio test. Table VI presents the results of the $T_2$ raw score means.

TABLE V

INTER-GROUP COMPARISONS OF $T_1$ RAW SCORE MEANS, FOUR CABLE-TENSION TESTS

| TEST | Exer-Genie $M_1$ | Trad. $M_1$ | diff | $SE_D$ | df | *t* |
|---|---|---|---|---|---|---|
| Trunk Extension | 55.2 | 57.6 | 2.4 | 6.74 | 30 | .351 |
| Knee Extension | 88.8 | 95.0 | 6.2 | 7.29 | 30 | .850 |
| Shoulder Extension | 51.2 | 56.2 | 5.0 | 3.68 | 30 | 1.350 |
| Ankle Plantar Flexion | 101.4 | 106.1 | 4.7 | 10.71 | 30 | .438 |

Note: For 30 df, the *t* ratio must be 2.04 in order to be significant at the .05 level of confidence.

TABLE VI

DIFFERENCES BETWEEN $T_2$ CABLE-TENSION STRENGTH MEANS

| TEST | Exer-Genie $M_2$ | Trad. $M_2$ | diff | $SE_D$ | df | *t* |
|---|---|---|---|---|---|---|
| Trunk Extension | 69.9 | 59.7 | 10.2 | 7.72 | 30 | 1.32 |
| Knee Extension | 109.5 | 106.1 | 3.4 | 8.26 | 30 | .41 |
| Shoulder Extension | 67.9 | 62.5 | 5.4 | 5.17 | 30 | 1.04 |
| Ankle Plantar Flexion | 121.3 | 103.5 | 17.8 | 10.62 | 30 | 1.68 |

Note: For 30 df, the *t* ratio must be 2.04 in order to be significant at the .05 level of confidence.

## Summary

The Exer-Genie group showed significant improvement in all individual cable tension tests at the .05 level or beyond. The traditional group failed to meet the necessary level of significance in the trunk extension, and showed a regression in mean score for the ankle plantar flexion. The traditional group did improve significantly in muscular strength in the shoulder extension and knee extension tests. While the Exer-Genie group showed the highest improvement over the traditional group in all areas except shoulder extension, these raw score mean gains were not statistically significant.

## III. COMPARISONS OF THE EXER-GENIE AND TRADITIONAL GROUPS ON CABLE-TENSION STRENGTH QUOTIENTS

Upon completion of the previous analyses of differences between Exer-Genie and traditional groups in which each of the separate cable-tension tests was examined, it occurred to the writer that a somewhat different analysis might be additionally productive. The following explanation will illustrate the rationale.

Rogers' Physical Fitness Index (P.F.I.) is a quotient based upon the sum of a number of achieved scores divided by a norm for those scores based upon age, sex and weight, multiplied by 100. Both intra-group and inter-group comparisons were made for the P.F.I. as a quotient, but not for the separate tests of which it is composed. This procedure, based on the quotient score alone, is customarily followed as the P.F.I. is regarded as a screening test and was so considered by the Broadfront personnel at Ellensburg, as well as in this study specifically. The cable-tension tests however, are by their nature, of individual diagnostic value in identifying specific areas of muscular weakness and thus represent one of several procedures applied after the initial screening by the P.F.I. test.

From an initial group of eighteen tests, Schopf (15: 515-522) statistically selected four which best represented the major muscular areas of the body and which were significantly related to criteria identified in earlier studies. He summed these four tests, referring to them as the Strength Composite which is analogous to the Rogers' Strength Index. By dividing an achieved Strength Composite by a norm based on sex, weight and age and multiplying by 100, the cable-tension Strength Quotient was obtained, which is analogous to the Rogers' P.F.I. score.

An examination of the information about each boy in the study indicated that all the boys at Cascade School (part of the Exer-Genie group) were from grade six, whereas those from Lincoln and Washington were from grades four, five, and six. This disparity suggested that a method of accounting for age and body weight was necessary if a true picture of changes in strength associated with methods of training was to be adequately portrayed. Thus, each boy's four cable-tension tests were summed, divided by the norm for his weight and age and multiplied by 100. Both intra-group and inter-group comparisons of these Strength Quotients were made.

## Intra-Group Comparisons

The Exer-Genie group's $T_1$ mean Strength Quotient of 67.6 was compared to its $T_2$ Strength Quotient of 80.1. The difference between these scores was 12.5 and the correlation was .760. The resultant *t* ratio of 3.78 was statistically significant at better than the .001 level of confidence, indicating that use of the Exer-Genie produced excellent cable-tension Strength Quotient gains; far greater than could be accounted for by chance.

The traditional group's $T_1$ mean Strength Quotient of 75.5 was compared to its $T_2$ mean of 72.1. The difference between the two represented a loss of 3.4 quotient points. Since the intent of the training was to produce strength gains (thus a one-tailed test) no *t* ratio was calculated. These comparisons are shown in Table VII.

TABLE VII

AMOUNT AND SIGNIFICANCE OF CHANGE IN CABLE-TENSION STRENGTH QUOTIENTS, INTRA-GROUP COMPARISONS

| GROUP | $M_1$ | $M_2$ | r | diff | $SE_D$ | df | *t* |
|---|---|---|---|---|---|---|---|
| Exer-Genie | 67.6 | 80.1 | .760 | 12.5 | 3.31 | 32 | 3.78 |
| Traditional | 75.5 | 72.1 | -- | -2.7 | -- | 28 | * |

* A mean loss in quotient scores

## Inter-Group Comparisons

The comparison of change in Strength Quotient scores between $T_1$ and $T_2$ for Exer-Genie and traditional groups was made by use of the Kruskal-Wallis one-way analysis of variance by ranks (39). The respective R values were 382.5 and 145.5 for Exer-Genie and traditional groups. The H statistic was

14.80, significant at well beyond the .001 level of confidence, indicating that the change in Strength Quotient associated with training made by the Exer-Genie group was far greater than that made by the traditional group (which, in fact, was a loss). Table VIII summarizes this information.

## Summary

In the P.F.I. test, each of the groups, Exer-Genie, traditional and control, gained significantly from $T_1$ to $T_2$ indicating that the respective types of physical education activity produced statistically significant increases. At $T_2$ however, none of the groups were significantly different indicating that any superiority in P.F.I. score associated with a training method could be attributed to chance.

In cable-tension strength, both Exer-Genie and traditional groups increased as a result of their respective developmental programs; Exer-Genie group increases were significant at .01 level of confidence in three tests and at .05 level in one test. The traditional group improved significantly at the .01 level of confidence in one test, at .05 level in one test, showed non-significant improvement in one test and regressed from $T_1$ to $T_2$ in the fourth test. A comparison between the two groups at $T_2$ indicated no significant differences between them.

# TABLE VIII

## KRUSKAL-WALLIS ONE-WAY ANALYSIS OF VARIANCE BY RANKS CABLE-TENSION STRENGTH QUOTIENTS, INTER-GROUP COMPARISONS

| EXER-GENIE GROUP | | | | TRADITIONAL GROUP | | | |
|---|---|---|---|---|---|---|---|
| $T_1$ | diff | $T_2$ | rank | $T_1$ | diff | $T_2$ | rank |
| 68.8 | -7.1 | 61.7 | 7.0 | 84.4 | -21.9 | 62.5 | 1.0 |
| 96.4 | -1.9 | 94.5 | 10.0 | 75.7 | -18.0 | 57.7 | 2.0 |
| 69.1 | 3.5 | 72.6 | 12.0 | 93.8 | -10.8 | 83.0 | 3.0 |
| 54.3 | 7.6 | 61.9 | 18.0 | 88.3 | -10.1 | 78.2 | 4.0 |
| 57.4 | 7.7 | 65.1 | 19.0 | 85.4 | -9.8 | 75.6 | 5.0 |
| 77.1 | 8.5 | 85.6 | 20.0 | 89.2 | -8.9 | 80.3 | 6.0 |
| 59.3 | 9.1 | 68.4 | 21.5 | 59.3 | -3.9 | 55.4 | 8.0 |
| 88.2 | 9.3 | 97.5 | 23.0 | 97.6 | -2.6 | 95.0 | 9.0 |
| 63.4 | 9.5 | 72.9 | 24.0 | 69.1 | -1.0 | 68.1 | 11.0 |
| 81.5 | 11.7 | 93.3 | 25.0 | 62.0 | 4.1 | 66.1 | 13.0 |
| 70.2 | 13.1 | 83.3 | 26.0 | 63.7 | 4.6 | 68.3 | 14.0 |
| 46.4 | 13.5 | 59.9 | 27.0 | 76.7 | 5.4 | 82.1 | 15.0 |
| 50.1 | 14.0 | 64.2 | 28.0 | 56.2 | 6.0 | 62.2 | 16.0 |
| 62.9 | 16.3 | 79.2 | 29.0 | 56.6 | 6.1 | 62.7 | 17.0 |
| 46.7 | 16.4 | 63.1 | 30.0 | 74.9 | 9.1 | 84.0 | 21.5 |
| 72.3 | 21.1 | 93.4 | 31.0 | | | | |
| 85.4 | 58.9 | 144.4 | 32.0 | | | | |
| | | | R = 382.5 | | | | R = 145.5 |

$$H = \frac{12}{N\ (N+1)} \sum \frac{R^2}{N} - 3\ (N+1)$$

$$= \frac{12}{32\ (33)} \left[ \frac{(382.5)^2}{17} + \frac{(145.5)^2}{15} \right] - 3\ (33)$$

$$= 113.80 - 99 = \chi^2 \quad 14.80 \quad \chi^2 = > .001 \ \ell/c$$

Within each section the $T_1$ quotients appear in the first column and the $T_2$ quotients appear in the third column. The difference between the quotients appears in the second column, while the consecutive rankings between groups appear in the last column. The summation of the rankings appear as the R values in each section. The H value was 14.80.

When Strength Quotients derived from age-weight norms were calculated for each of the two groups and subsequently compared, it was found that the Exer-Genie group gained impressively over its own $T_1$ mean beyond the .001 level of confidence; the traditional group decreased in mean Strength Quotient. When the Kruskal-Wallis non-parametric one-way analysis of variance by ranks was applied for significance of difference between groups, the Exer-Genie group demonstrated clear superiority over the traditional group at a statistical level exceeding the .001 level of confidence.

CHAPTER V

# SUMMARY, CONCLUSIONS AND RECOMMENDATIONS

## I. SUMMARY

### Purpose

The trend in American life is toward inactivity, according to authorities in the field of physical education. With this thought in mind, the writer initiated this study involving the Exer-Genie as a physical conditioning device for the development of physical fitness in youth. Background experiences in the use of the Exer-Genie for physical education exercises prompted the writer to investigate it as a device for building specific muscular strengths.

Briefly restated, the purposes of this study were to: (1) compare the Exer-Genie with a more traditional developmental physical education program and a typical physical education program not having developmental aspects, for developing physical fitness in elementary school boys; and (2) to compare the development of specific muscular strengths in a program using the Exer-Genie with the same specific muscular strengths in a traditional developmental program.

Boys in the fourth, fifth and sixth grades who scored ninety and below on the Modified Form of the Oregon Physical Fitness Index were chosen from the Ellensburg and Kittitas, Washington school districts. The study was limited to participation in the various programs for a ten week period. Both experimental groups participated in their programs for a total of 2,400 minutes of class time. The control group had 2,250 minutes of total physical education class time.

## Procedures

The P.F.I. test was used as a screening test to identify the low fitness boys. Those who scored ninety and below were given the P.F.I. a second time in order to be certain of the accuracy of the original score. The subjects participating in the Ellensburg Broadfront developmental physical education program were given Clarke and Schopf's cable-tension test battery to test for particular muscle group weaknesses (15). After the results of the cable tensiometer tests were compared to Harrison's and Stolsig's cable-tension age norms, the writer prescribed Exer-Genie exercises for group A on the basis of the weaknesses shown.

At the duration of the ten week period, all groups were given the P.F.I. test. Experimental group A and experimental group B were given the cable tensiometer muscular strength tests in addition to the P.F.I. test.

In order to evaluate statistically the change in P.F.I. scores within the traditional, Exer-Genie, and control groups, their respective $T_1$ tests were compared to their own $T_2$ tests by means of the *t* ratio applied to correlated groups.

All three groups were compared for significance of difference in P.F.I. gains by means of the Kruskal-Wallis H test, a one-way analysis of variance (39).

The changes in cable-tension strength scores within the Exer-Genie and the traditional group were statistically analyzed by comparing their own $T_1$ test scores to their own $T_2$ test scores by use of the _t_ ratio applied to correlated groups.

The $T_1$ cable-tension raw score means were compared between Exer-Genie and traditional groups to determine if they could be considered from the same strength population. $T_2$ scores were then compared between the two groups by use of the one-tailed _t_ ratio test for significance of difference between means for uncorrelated groups.

Strength Quotient values were calculated for each subject as provided for by Schopf's cable-tension battery for boys in the fourth, fifth, and sixth grades. The comparison of the quotient scores between groups was accomplished by using the Kruskal-Wallis one-way analysis of variance by ranks test. The differences in cable-tension Strength Quotients between the Exer-Genie and the traditional groups were statistically analyzed by comparing their own $T_1$ quotients to their own $T_2$ quotients and using the _t_ ratio as applied to correlated groups.

## II. CONCLUSIONS

### P.F.I. Test Results

The Exer-Genie group showed a mean gain of 17.4 on the P.F.I. test for the ten week period. This resulted in a $t$ ratio of 7.67 which greatly exceeded the .01 level of confidence. This level of significance points out the value placed on the Exer-Genie as an innovative device for building fitness when used in the manner prescribed in this study. The fact should be brought out that the Exer-Genie can be used with ease and safety by any student. This is an asset to those instructors and students alike who use the instrument.

The traditional group showed the greatest within group gains, achieving a mean gain of 27.3 points and a $t$ ratio of 11.38 which was well beyond the .01 level of significance. It is appropriate to point out the great improvement made by this Ellensburg Broadfront traditional developmental program, but at the same time, it should be noted that this program required much more equipment than the Exer-Genie group which may not be available to school districts or communities with less financial support than the Broadfront Program.

The mean gain of 17.0 by the Kittitas control group points out the capabilities of a well organized daily physical education program for elementary school children. The *t* ratio for this group was 4.78 which was well beyond the .01 level of significance. The fifteen minutes of daily calisthenics is not an innovative method of exercise but it is pertinent to say that P.F.I. gains are the result of appropriate exercise.

The Kruskal-Wallis one-way analysis of variance test showed that the traditional group, although ranking the highest, did not significantly improve over the Exer-Genie group or the control group. This is due to the significant levels of improvement made by all three groups during the ten week study.

The results of the study have shown that the Exer-Genie may be considered a worthwhile device for the improvement of physical fitness for elementary school boys.

Cable Tensiometer Test Results

In analyzing the raw score means, the Exer-Genie group improved well beyond the .01 level of confidence in shoulder extension, knee extension and ankle plantar flexion. The trunk extension improved at the .05 level. This significant gain in cable tension strength for all four tests is the result of prescribed Exer-Genie exercises for specific muscle group weaknesses.

The importance of diagnostic testing and treating the findings of such testing by prescribing specific exercises is pointed out in the improvement made by the Exer-Genie group. The Exer-Genie device appears to be responsible for making these gains possible because of its usability in building strength for specific muscle groups.

The traditional group did not show significant gains in specific muscle group weaknesses involving the trunk extension and ankle plantar flexion. The ankle plantar flexion test results showed a mean loss between $T_1$ and $T_2$. The knee extension test showed an improvement beyond the .01 level, and the shoulder extension showed a mean improvement at the .05 level of confidence. The lack of universal improvement appears to be caused by the fact that the traditional program was designed to improve general physical fitness, rather than the improvement of specific muscle group weakness as diagnosed by follow-up testing.

While the Exer-Genie group showed the highest improvement over the traditional group in all individual tests except shoulder extension, these gains were not statistically significant when comparing raw score means.

As a result of calculating the Strength Quotients which utilize a subject's body weight, and age, a more realistic picture of the results was obtained. The Exer-Genie group showed a significant improvement beyond the .001 level over the traditional group in the cable-tension battery.

The Exer-Genie group quotient scores for $T_1$ were compared to their $T_2$ scores which resulted in a $t$ ratio of 3.78 which was significant beyond the .001 level of confidence. The traditional group showed a mean loss of 3.4 points for the same comparison. The results of this comparison of Strength Quotients brings to focus the importance of testing for specific muscular weaknesses and prescribing particular exercises to correct these deficiencies as well as the importance of equalizing comparisons between subjects by use of age-weight norms when subject to subject matching is impossible. The Exer-Genie was used as a remedial tool and proved to be an effective instrument when used in this manner.

The results of this study have shown that the Exer-Genie is not only a valuable device for physical conditioning, but when used in a prescribed manner of exercise, is an effective technique for improving specific muscular weaknesses.

## III. RECOMMENDATIONS

The results of this investigation have affirmed the writer's belief that the Exer-Genie can be used as an effective tool for physical conditioning. This research has led the writer to make the following recommendations:

1. Testing, and prescribed treatment, should be employed by all schools to determine specific muscular weaknesses

of school children.

2. This study was based on a ten week period only. The within group gains were significant enough to recommend a full year program of developmental physical education for those students needing special attention.
3. The gains made by the Ellensburg traditional group may be attributed to the qualified personnel instructing physical education at the elementary school level. It is recommended that school districts should endeavor to place such qualified instructors at all grade levels.
4. It is further recommended that the Exer-Genie should not be used as the only technique for improvement of sub-fit youth, but be incorporated into a program with other activities designed for developmental physical education.
5. The Ellensburg Broadfront program is financed through federal funding. It is recommended that school district personnel make a concerted effort to encourage all members of the local, state, and federal agencies to support and finance programs in physical education for all grade levels. All children should have the opportunity of participating in programs that are designed to maintain optimum levels of physical fitness.

6. The Exer-Genie group was divided between two Ellensburg schools, Lincoln and Cascade. The Cascade group was asked to give up approximately fifteen minutes of their free time before school, three times a week, to work on the Exer-Genie. Taking Cascade students away from their free play had an adverse affect upon the results of the study. The Lincoln group, with ten subjects, showed a mean gain of 22.0 P.F.I. points for the ten week period. The Cascade group, with seven subjects, showed a mean gain of 11.0 P.F.I. points for the ten week period. With this comparison in mind, it is recommended by this writer that scheduling of developmental physical education classes should be during the regular school day rather than during the subjects' free play time.
7. Finally, it is recommended that further study be done with the Exer-Genie. The Exer-Genie should be compared with traditional methods of weight-lifting and calisthenics.

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# APPENDIX A

## PICTURES AND DESCRIPTION OF THE EXER-GENIE PROGRAM

## DESCRIPTION OF THE EXER-GENIE PROGRAM

The experimental group A used the circuit training technique consisting of six stations: the big four using the curl technique; the clean technique; two man rowing; forward bend; standing bench press; and jogging 440 yards.

A description of the stations described below are taken from the Exer-Genie manual and are the techniques prescribed by the Exer-Genie Company (17).

### Big Four Curl Technique

The big four using the curl technique was accomplished by standing squarely on the stand board, with knees bent, shoulders hunched together, back arched, stomach in, arms straight down, and not resting on legs. The trail line was held by the companion with whom the student was working. At this point, the isometric contraction was held for a count of ten. The subject tried as hard as possible to raise head and shoulders for ten seconds. The dead lift was started as the first part of the isotonic phase of the big four. Without relaxing, the resistance was released enough so that the trail line being held by the companion would move the line through the Exer-Genie. The back was straightened by pushing the hips forward and pulling the shoulders back. The head was kept high and the knees were flexed more to keep the subject balanced. The second phase of the big four was the leg press. The resistance was increased by the companion who tightened the finger pressure on the trail line while the subject straightened the legs and tried to push the legs through the floor. The third phase of the big four was accomplished by bringing the hands toward the chin by bending the elbows while keeping the upper arms alongside the chest and waist. The fourth phase of the big four was the military press and was accomplished by reversing the hand grip after the curl technique had been completed. The hands were pushed as high as possible over the head and the subject was required to include the toe extension at the end of the military press.

### Big Four Clean Technique

The big four using the clean technique was done exactly the same as the previously described big four, except for substituting the clean lift for the curl in phase three. The clean was done by gripping the handles of the Exer-Genie palms down, and pulling handles toward the chin with the hands kept close to the body.

### Two Man Rowing Exercise

The two man rowing exercise was accomplished by having the Exer-Genie attached to a wall hook approximately three inches from the floor. The subjects worked in pairs starting from a sitting position with the arms extended. One partner held resistance while the other partner started a rowing motion after a ten second isometric contraction.

Forward Bend

The forward bend was accomplished by attaching the Exer-Genie to a wall hook approximately six feet high. The subjects again worked in pairs with the partner supplying the resistance on the trail line as the rope worked through the Exer-Genie. The performing subject started with his head bent forward and the shoulders against the wall. The hands grasp the handles palms down behind the neck. The isometric contraction was held for a count of ten and without pausing, the resistance was relaxed by the partner and the subject bent forward as far as possible, using only the stomach muscles, and the handle was kept behind the neck.

Standing Bench Press

The standing bench press was accomplished by anchoring a hook approximately five feet off the floor. A three foot piece of pipe was substituted for the wooden handles. The subjects again worked in pairs; one partner held the trail line while the companion stood with his back to the wall, grasping the pipe with the hands, palm out, and arms flexed, but pushing out for an isometric contraction to ten. The partner then relaxes resistance and the subject pushes the handle forward, extending the arms to a full extension.

These exercises were repeated three times each by every subject. The jogging was done once by each subject during each class period.

EXER-GENIE PROGRAM

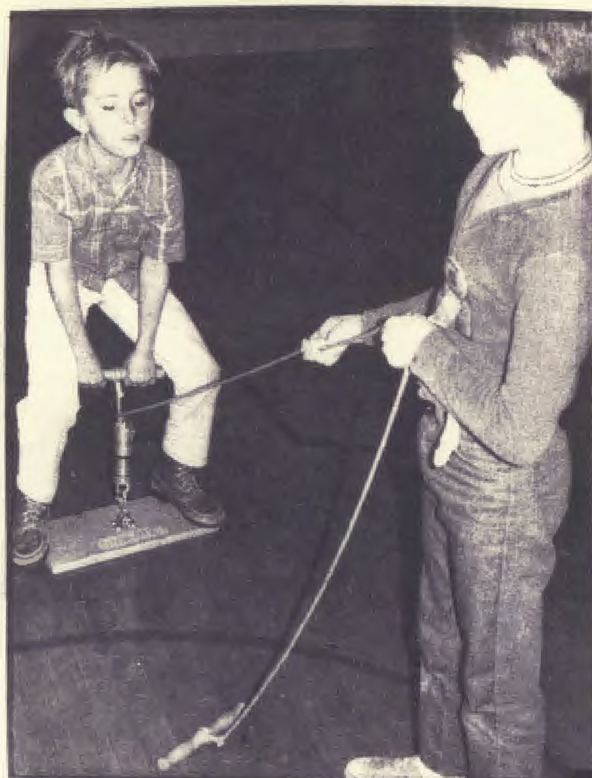

Figure 1. Big Four

Figure 2. Rowing Extension

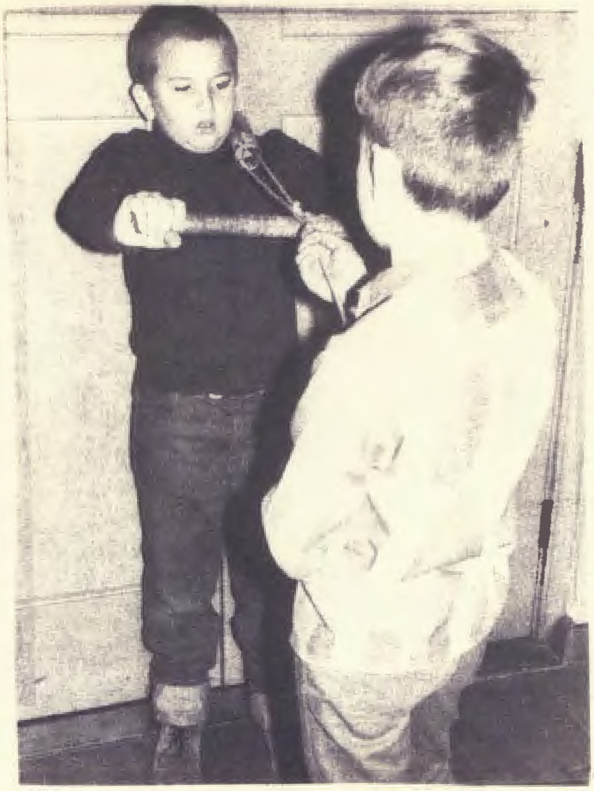

Figure 3. Bench Press

Figure 4. Forward Bend

# APPENDIX B

# PICTURES OF THE TRADITIONAL PROGRAM AND CABLE-TENSION STRENGTH TESTS

TRADITIONAL PROGRAM

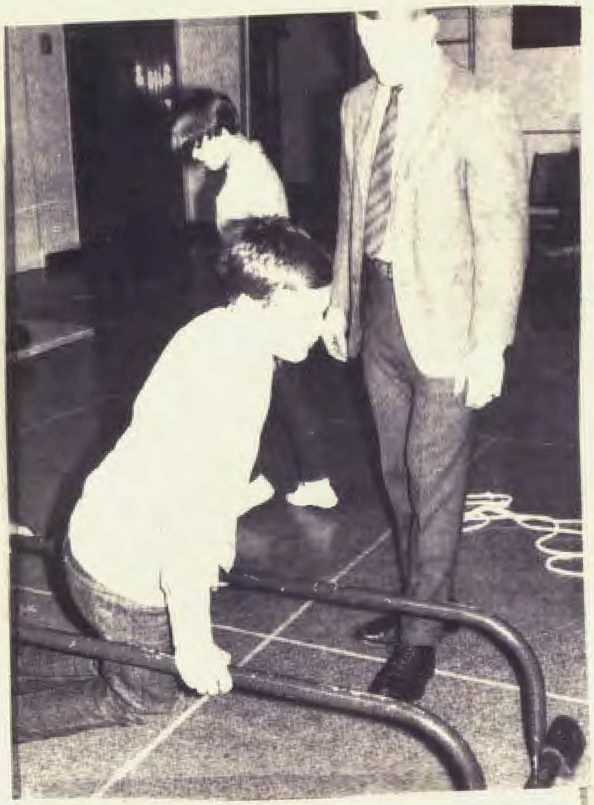

Figure 5. Weight Lifting

Figure 6. Arm Walk

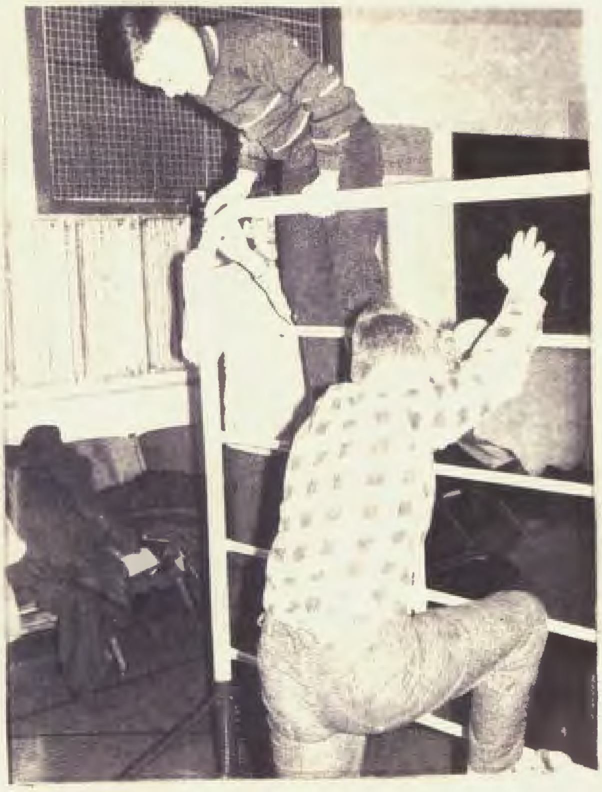

Figure 7. Climbing Fence

Figure 8. Overhead Ladder

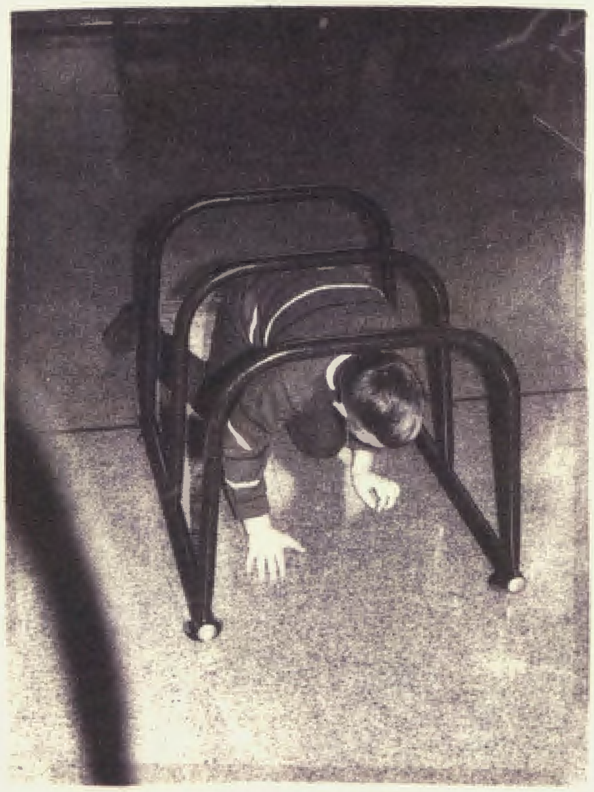

Figure 9. Tunnel

CABLE TENSION STRENGTH TEST

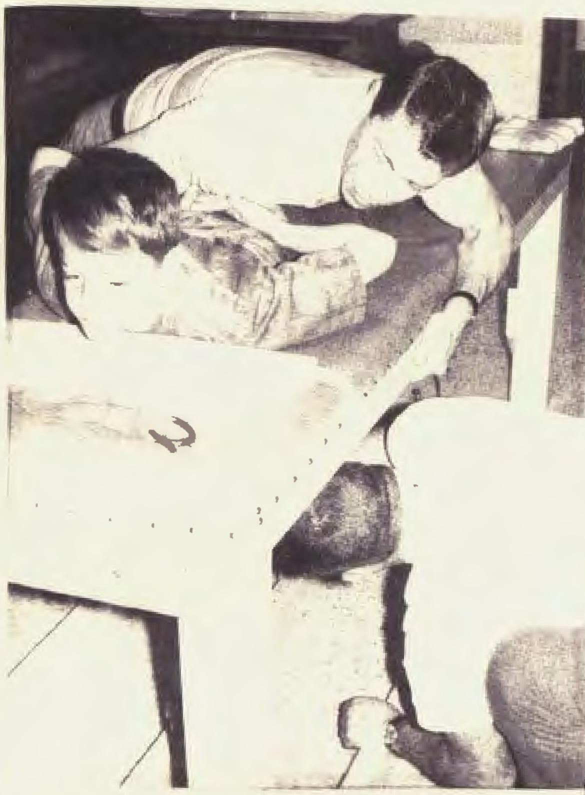

Figure 10. Trunk Extension

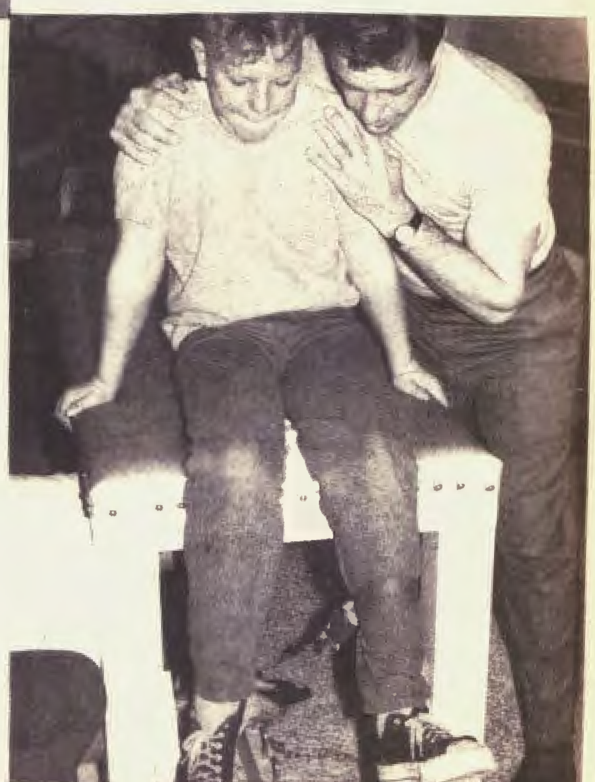

Figure 11. Knee Extension

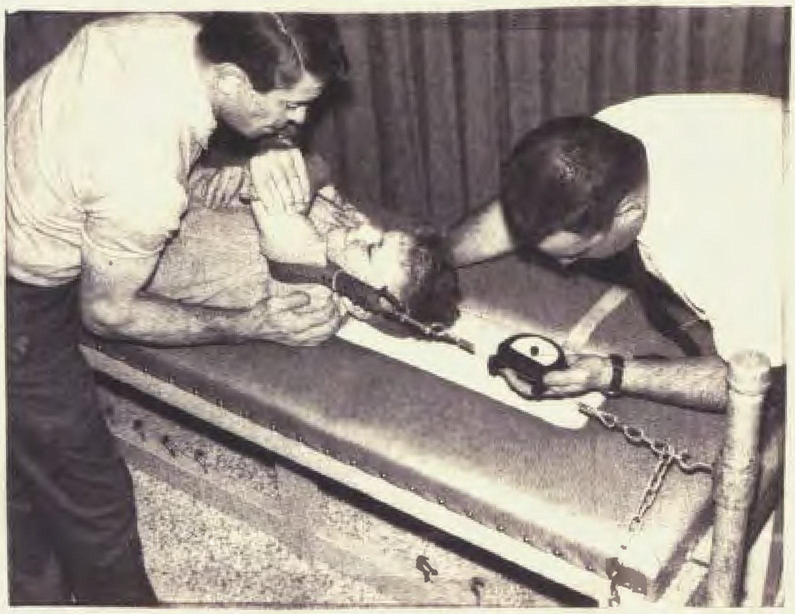

Figure 12. Shoulder Extension

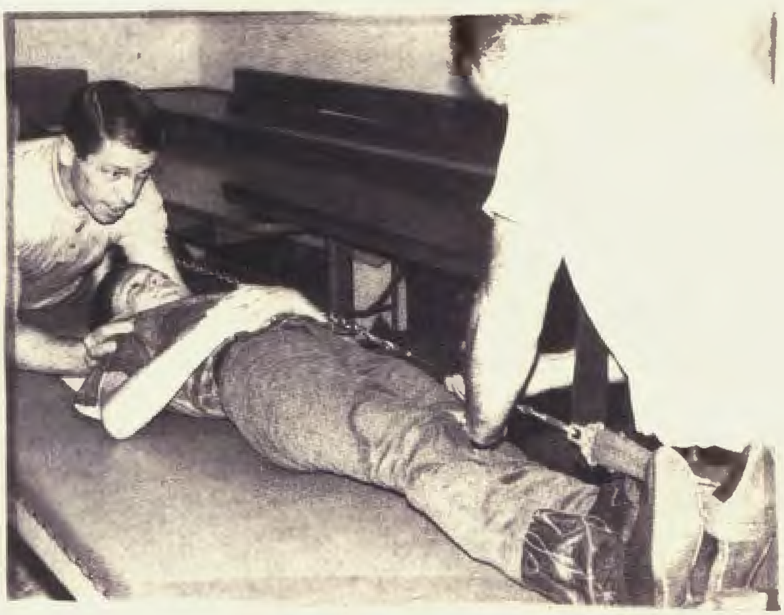

Figure 13. Ankle Plantar Flexion