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A study of the effects of an isometric training program on muscular endurance and on muscular explosive power

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A STUDY OF THE EFFECTS OF AN ISOMETRIC TRAINING PROGRAM ON MUSCULAR ENDURANCE AND ON MUSCULAR EXPLOSIVE POWER

by

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CHAPTER I

THE PROBLEM AND ITS SCOPE

Introduction - Authorities in the field of Physical Education were considering more economical ways of developing muscular strength, endurance and explosive power. Rarick and Larsen[1] reported the following.

> THE STUDIES of DeLorme (3), DeLorme and Watkins (4) and and the more recent investigations of Hettinger and Muller (6,7) have revived interest in seeking economical methods for the development of muscular strength. The results of these studies indicate that the time required for building static muscular strength can be substantially reduced over that previously believed to be necessary. The effectiveness of DeLorme's heavy resistance, low repetition exercise program in strength development had been substantiated by Houtz, Parrish and Hellebrandt (9), Hoag (8), and Darcus and Salter (2).
>
> Whereas DeLorme experimented with isotonic exercise, Hettinger and Muller used short periods of static muscular effort with the tension level maintained at two-thirds maximum isometric strength.

Since Hettinger and Muller's experiments with isometric contractions, nation wide interest has been stimulated concerning its use. The following summary of an article from Sports Illustrated[2] presents some of the various claims concerning the effects of isometric exercises.

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[1]G. Lawrence Rarick and Gene L. Larsen, "Observations on Frequency and Intensity of Isometric Muscular Effort in Developing Static Muscular Strength in Post-Pubescent Males," Research Quarterly 29: 333-341, October, 1958.

[2]Gilbert Rogin, "Get Strong Without Moving," Sports Illustrated, 15: 19-21, October 30, 1961.

Notre Dame football players, the San Francisco 49ers and the Pittsburgh Pirates baseball team have been using isometric contractions in their training program. It was felt that training with isometric exercises increased strength and was a factor in the low injury rate which was experienced by the players. Weight lifter Louis Piecke, after using isometric exercises as a part of his training program was able to press forty-five pounds more and snatched forty-five pounds more so that he was able to make the United States Olympic Weight Lifting Team. Professor Gene Logan of the University of Southern California, where high jumper Bob Avant was a student, developed a program of isometric exercises for the jumper. In two months Avant went from a six foot eight inch jump to a seven foot jump. The assumption was made that isometric training was a contributing factor. Francis Drury and trainer Marty Broussard have developed special isometric equipment for the University of Southern California sprinters and football players. They expressed their confidence in isometric training by predicting that all world weight lifting records would be broken in the following year and that the track and field records would fall within two years. Bob Hoffman, the Olympic weight lifting coach stated that the results of isometric training are miraculous.

Though these various claims have been made regarding the effects of isometric exercises, not enough experimental work has been done to prove conclusively that these results can be obtained; or that they cannot be obtained.

The inconclusiveness of these claims, the recent rise in interest, and the implications of this type of exercise for muscular development

have been motivating factors in prompting the author to conduct this study.

I. THE PROBLEM

Statement of the Problem - The purpose of this study was to determine the effects of isometric exercises upon (a) muscular endurance of the upper extremities and the shoulder girdle as measured by the ability to do chin ups and (b) muscular explosive power of the legs as measured by the vertical jump.

Analysis of the Problem - In planning a program to develop muscular endurance and muscular explosive power as measured by chinning and the vertical jump, isometric exercises relating to these two factors had to be determined.

An initial test of muscular endurance and muscular explosive power was given by having the students complete their maximum number of chin ups and maximal vertical jump.

A program of isometric exercises was administered to develop the main muscle groups involved in chinning and in the vertical jump. A periodic test of chinning and vertical jump ability was given at the end of four weeks and a final test was given at the end of eight weeks.

The last part of the problem was to determine statistically whether or not the training program caused a significant change in chinning and jump reach abilities.

II. BASIC ASSUMPTIONS

It was assumed that chin ups would measure muscular endurance of the upper extremities and that the vertical jump would measure explosive muscular power of the legs.

It was assumed that the positions selected for the exercises would be adequate to develop the muscle groups involved in the test exercises.

It was also assumed that the students who volunteered would not do special exercises on their own.

III. DEFINITIONS OF TERMS USED

1. Isometric exercise -- any kind of effort in which the muscles strain and tense against an immovable object or against each other without movement of the joints.[3]

2. Muscular endurance -- ability to perform submaximal activities requiring high muscular exertion for short periods of time. Example: Chinning.[4]

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[3]Gilbert Rogin, "Get Strong Without Moving", Sports Illustrated, 15: 19-21, October 30, 1961; Peter V. Karpovich, M.D. M.P.E., Physiology of Muscular Activity (Philadelphia: W. B. Saunders Company, 1959), pp. 8-13; Laurence E. Morehouse, Ph.D. and August T. Miller, Jr., Ph. D., Physiology of Exercise (St. Louis: The C. V. Mosby Company, 1959), p. 27.

[4]H. Harrison Clarke, Application of Measurement to Health and Physical Education (Englewood Cliffs, New Jersey: Prenctice-Hall, Inc., 1961) pp. 221-222; C. H. McCloy, "Endurance," The Physical Educator, V 5: 9-23, March, 1948.

3. Muscular (explosive) power - ability to release maximal muscular force in the shortest period of time.

Example: Standing broad jump.[5]

IV. LIMITATIONS OF THE STUDY

This study was limited to forty volunteer male college students in the required physical education program at Montana State University during the 1962 winter quarter.

The training period was limited to eight weeks, one session per day for five days a week.

Strength per se was not measured. (It is recognized that strength is a part of endurance and generally increases through a program of isometric exercises.)[6]

Subjects were retested only twice to check the results of this program so as not to affect the training of the individual.[7] One test was given at the end of four weeks and a second test was given at the end of eight weeks

Tests of the significance of results of the exercise progress were limited to the .01 level of confidence.

V. NEED FOR THE STUDY

There is a need to contribute more scientific information

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[5]H. Harrison Clarke, Application of Measurement to Health and Physical Education (Englewood Cliffs, New Jersey: Prentice-Hall Inc., 1961), pp. 221-222.

[6]Erich A. Muller, M.D., "The Regulation of Muscular Strength," J.A.P.M.R., pp. 41-47, March-April, 1957.

[7]Ibid.

concerning the effectiveness or lack of effectiveness of isometric exercises.

There was a need for investigation of economical methods of developing muscular strength, power and endurance.

VI. SUMMARY

Chapter one has given a brief description of the problem and the definition of certain terms as they were used for this study. Chapter two will be a summary of the related literature.

CHAPTER II

SURVEY OF RELATED LITERATURE

I. INTRODUCTION

Isometric exercises are those exercises involving static muscular contractions. The muscles tense and strain against an immovable object, or against each other, without movement occurring in the joints involved. To gain the greatest amount of development in a given period of time, some authorities recommended single daily exercise bouts of maximum contraction for a few seconds at least five days a week, for each type of exercise involved.

A survey of the literature revealed the various research studies done to evaluate the effectiveness of various techniques of administering to isometric exercises.

There was considerable controversy over the effects of isometric contractions on muscular development. Rogin quotes H. Steinhaus as stating that isometric contractions do not increase endurance and refers to Peter Karpovich's statement that there are more claims than evidence, that endurance is not increased.[1] G. T. Adamson stated that this problem is not solved, since test results following isometric training do not always indicate the same results.[2] The author, in an attempt to help

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[1]Gilbert Rogin, "Get Strong Without Moving," Sports Illustrated, 15: 19-21, October 30, 1961.

[2]G. T. Adamson, "Effects of Isometric and Isotonic Exercise on Elbow Flexor and Spine Extensor Muscle Groups," Health and Fitness in the Modern World, pp. 172-180, 1961.

find some of the effects of isometric exercises, had to establish a testing and a training program.

II. REVIEW OF TEST EXERCISES

The author's purpose was to determine some of the effects of isometric exercises upon muscular endurance of upper extremities and shoulder girdle and upon muscular explosive power of the lower extremities. To do this, isotonic tests to measure each of these two factors had to be determined.

C. H. McCloy mentioned chin ups as a muscular endurance type of activity, and indicated that the development of muscular endurance involves the following: Strengthening of muscle fibers so fewer could be used for the identical amount of work; the opening of many capillaries to supply blood to the greater muscle mass; and certain chemical changes within the muscle which facilitate more efficient functioning. In general, he stated that muscular endurance involves strength and muscle recovery power.[3]

Nelson stated, in his thesis on a Study of Arm and Shoulder Strength that chin ups are considered a muscular endurance exercise.[4]

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[3]C. H. McCloy, "Endurance," The Physical Educator, V 5: 9-23, March, 1948.

[4]Jack Kimberly Nelson, "A Comparison of Arm and Shoulder Strength of College Men Today With That of College Men 16 Year Ago:" Master's Thesis, Montana State University, pp. 5-7, 1961.

Larson, who supervised the Army Air Force Physical Training Program, also considered chinning a muscular endurance activity.[5]

On the basis of the above information, chin ups were selected as the test exercise for measuring muscular endurance of the upper extremities and shoulder girdle.

H. H. Clarke defined muscular explosive power, using the standing broad jump as an example, as the ability to release maximum muscular force in the shortest time.[6]

Bovard, Cozens, and Hagman considered the vertical jump as the simplest test to determine an individual's explosive muscular power.[7]

On the basis of this information and because of the ease of administration, the vertical jump was used by the author as a measure of muscular explosive power.

III. MUSCLES AND MOVEMENTS INVOLVED IN TEST EXERCISES

To insure that the major muscle groups used in chinning and in the vertical jump were exercised during the isometric training program, it was necessary to analyze the movements and muscles involved.

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[5]Leonard A. Larson, "Some Findings Resulting From the Army Air Force Physical Training Program," Research Quarterly, 21: 144-164, October, 1950.

[6]H. Harrison Clarke Ed.D., Application of Measurement to Health and Physical Education (Englewood Cliffs, N. J.: Prentice-Hall, Inc., 1959) p. 222.

[7]John F. Bovard, Frederick W. Cozens and E. Patricia Hagman, Tests and Measurements in Physical Education, (Philadelphia: W. B. Saunders Company, 1949) p. 138.

Scott, in analyzing the muscles involved in chinning, stated that the grip is maintained on the bar by the flexor longus pollicis, flexor profundus digitorum and flexor sublimis digitorum. Flexion of the elbow is produced by the biceps, brachialis, pronator teres and brachioradialis. Shoulder extension is performed by the latissimus dorsi, teres major, and the lower pectoralis major. The movement of depression and downward rotation of the scapula is performed by the pectoralis minor, rhomboids, and third part of the trapezius. Other muscles are used to stablize the trunk for a firm origin of some muscles involved directly in chinning.[8] When a person returns to the extended position after completing a chin up, he uses an eccentric contraction of the same muscles.

In the mechanical analysis of chinning, Scott noted that it is difficult to initiate the upward movement of the body from the fully extended hanging position for two reasons. One is the force of inertia, and the second reason is the position and angles of pull of the muscles involved. The muscles involved in chinning have their least effective angle of pull while the arms are in this extended position.

The angle of pull of the elbow joint muscles improves as flexion occurs up to an angle of ninety degrees. Flexion of the elbow helps extension of the shoulder by increasing tension of the shoulder action of the triceps.[9]

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[8] M. Gladys Scott, Analysis of Human Motion (New York: Appleton-Century-Crofts Inc., 1942), pp. 290-291.

[9] Ibid.

In analyzing the movements in the vertical jump, the author restricted this analysis to the extension of the knees, extension of the hips and plantar flexion of the ankles. Dr. Duvall stated that in knee extension, the rectus femoris and vastus intermedius act directly for the movement, while the medial and lateral vasti, with their fibers curving diagonally around from the back of the femur, function indirectly. These last two muscles also function to stabilize the patella during the movement.[10]

Dr. Rasch and Dr. Burke listed four hip extensor muscles: the gluteus maximus, biceps femoris, semitendinosus and semimembranosus. For plantar flexion they listed the following muscles: gastrocnemius, soleus, tibialis posterior, peroneus longus, peroneus brevis, flexor hallucis longus and flexor digitorum longus.[11]

IV. REVIEW OF ISOMETIC EXERCISES FOR TRAINING

The author simplified the training program by having the subjects perform two exercises in which they would use the same muscle groups in the isometric exercises that would be used in the test exercises. One exercise would develop the major muscle groups used for chinning, and the other would do the same for those needed in the vertical jump. The positions established by the author for the performance of training exercises

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[10] Ellen Neall Duvall, Ph. D., Kinesiology the Anatomy of Motion, (Englewood Cliffs, N J.: Prentice-Hall, Inc., 1959), pp. 86-87.

[11] Philip H. Tasch, Ph. D., F.A.C.S.M. amd Roger K. Burke, Ph.D., F.A.C.S.M., Kinesiology and Applied Anatomy (Philadelphia: Lea and Febriger, 1959), pp. 224-227.

in both the chinning and the vertical jump are described in detail on pages 29 and 30 in Chapter III.

V. ISOMETRIC EXERCISE EQUIPMENT

Bob Pettit of the St. Louis Hawks basketball team used an isometric exercise which he believed would aid his jumping ability in basketball. This exercise consisted of straining from a semi-crouch position against a steel horizontal bar supported by two uprights. The bar ran laterally across the top of the shoulders. This bar held the body down while the individual applied pressure against it by trying to extend his knees, hips and ankles.[12] For this study a similar apparatus was constructed for the development of muscular explosive power of the legs.

Apparatus for the isometric chinning position was devised by the author and is explained on page 27 in Chapter III.

VI. DETERMINING BODY POSITIONS FOR ISOMETRIC EXERCISES

The literature reviewed failed to indicate the best angle for which internal muscular force could be developed during a program of isometric contractions. Since the angles had to be determined, it was decided to utilize the angles at which the muscles could exert their maximum external force on the bony levers.

William and Stutzman state that muscles cannot be tested directly because they are attached internally. They must be tested through their

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[12] Op Cit., Gilbert Rogin

lever system. In testing strength through the range of motion for the upper extremities, they found that elbow flexion strength could produce its maximal external force or lever rotation force, when the elbow joint was at a ninety degree angle. Rotational force dropped off as the joint angle changed in either direction from this point. Shoulder joint extension tests showed the average maximal strength angles to be between ninety and one hundred and twenty degrees of flexion.[13]

Tests, by Ann Downer, M.A., on thirty adult women, twenty to twenty-five years of age showed that strength increased in elbow flexion to ninety degrees (maximal power angle) and decreased beyond this angle. She also found that the greatest strength of flexion occurred when the forearm is in the mid-position between supination and pronation.[14]

Philip Rasch tested twenty-four male adults to find the effects of the position of the forearm on strength of elbow flexion. He found that the greatest tension could be exerted when the forearm was in the midposition, halfway between supination and pronation, and the least when in the pronated position.[15]

To measure shoulder extension strength with a tensiometer, H. Harrison Clarke changed the shoulder joint angle of measurement from one

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[13]Marian William, Ph. D., and Leon Stutzman, M. A., "Strength Variation Through the Range of Joint Motion," Physical Therapy Review, 39: 145-152, March, 1959.

[14]Ann H, Downer, M.A., "Strength of the Elbow Flexor Muscles," The Physical Therapy Review, 33: 68-69, February, 1953.

[15]Philip J. Rasch, "Effect of Position of Forearm on Strength of Elbow Flexion," Research Quarterly, 27: 333-337, Oct., 1956.

hundred and thirty-five degrees to ninety degrees of flexion. This angle was more suitable for strength measurement.[16]

Clarke stated that if rings are not available for chin ups, then a horizonal bar can be substituted and an over grip should be used.[17]

R. T. Devitt stated that the over grip should be used on a horizontal bar even though about 2.08 more chin ups can be done using the under grip method. His reason was that since all climbing is done in this manner, we should perform chin ups in this way. He stated that this is the grip recommended by the armed services.[18] The over grip method was selected for this study.

Aileeen Carpenter measured the effectiveness of muscular pull in knee flexion for subjects at six different angles and each was given a strength test each day for eighteen days. The subjects rotated so that each had three turns at each angle. The position permitting greatest strength was found to be from one hundred and fifteen degrees to one hundred and twenty-four degrees of knee flexion; one hundred and twenty-five degrees to one hundred and thirty-nine degrees was second and the results obtained of angles below one hundred and fifteen and above one

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[16]H. Harrison Clarke, "Improvement of Objective Strength Test of Muscle Groups by Cable-Tension Methods," Research Quarterly, 21: 399-419, December, 1950.

[17]Op. Cit., H. Harrison Clarke Ed. D., Application of Measurement to Health and Physical Education.

[18]R. T. DeWitt, "A comparative Study of Three Types of Chinning Tests," Research Quarterly, 15: 249-251, October, 1944.

hundred and thirty-nine degrees were definitely inferior.[19]

William and Stutzman, in testing strength through the range of motion for the lower extremities, stated that the optimum angle of power for knee extension was found to be between sixty and ninety degrees of knee flexion.[20]

VII. METHODS OF PERFORMING ISOMETRIC EXERCISES

Dr. Erich A. Muller renewed interest in isometric exercises during 1952. His experiments on building strength were done entirely with isometric contractions.

Muller performed experiments to establish how intensely, how long, and how frequently a force is needed to build muscle strength and enlargement. For reason of accuracy and measure-ability, Muller chose a program of isometric static contractions rather than isotonic contractions.

Dynamometers were used by Muller for both the training contraction and the measuring of maximal strength. Only one short maximal contraction was used when measuring the subject's maximal strength. The training contraction was done for a specified length of time and was of definite intensity. The daily contractions represented specific fractions (one-third to two-thirds) of the maximal strength. From this, Muller determined how intense a force must be to stimulate muscle hypertrophy. Muscle strength increased when the training load was as little as one-third of maximal strength. It increased progressively with contractions

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[19]Aileen Carpenter, "A Study of Angles in the Measurement of the Leg Lift," Research Quarterly, IX: 70-72, October, 1938.

[20]Op Cit., Marian William.

up to approximately two-thirds of maximal strength. Contractions of varying degrees of strength from two-thirds effort to maximal produced nearly equal effects.

Next, Muller sought to determine the time a contraction must be sustained to effect a strength increase. He found that a contraction which was held six seconds resulted in as much increase in strength as longer contractions (up to full exhaustion in forty-five seconds).

Finally, he made tests for the frequency of exercise bouts necessary to effect an increase in strength. The frequency of exercise periods varied from one in two weeks up to seven per day. Less than one contraction per day reduced the speed of increase in strength; more than one a day gave no better results than one per day.

From his tests, Muller concluded that "Increasing strength is due to oxygen deficiency within a muscle fiber. But due to the distribution of muscle fibers, not all of them involved in the exercise suffer the oxygen deficit until two-thirds maximum load is exerted upon the muscle."

For ordinary practice, Muller advised that maximal contractions be used instead of fractions of maximal effort. The following are some of his reasons for this: (1) No dynamometer is needed and force can be exerted against any available resistance. (2) The increased intensity of the training load leads to more rapid muscle strength. (3) Measurement of maximal strength, if a dynamometer is used, also will be a maximal training contraction. (4) There is a saving in training time and apparatus.

Following these experiments dealing with muscle strength increase, Muller wrote of investigations into muscle atrophy. He found that

complete inactivity of trained muscle caused strength loss four times as quickly as the loss in a trained muscle that was used normally after training was stopped. The atrophied muscle, however, regained strength four times as fast as the normal muscle (not atrophied) when both were given isometric exercises. To prevent atrophy, it was necessary to make at least one-fifth maximal contraction per day; a contraction of one-twentieth of maximal strength gave atrophical results.

In further studies on maintenance and persistence of normal strength, Muller mentioned these findings: Muscle strength which had increased from daily training contractions done for twenty weeks, receded after training was stopped at approximately the same rate; eleven weeks of daily contractions followed by twelve weeks of weekly contractions led to a much slower drop in strength; when the muscles were trained once a week for forty-six weeks, their strength at the end of seventy weeks was still forty-two per cent higher than when training began.

Muller also points out some advantages of static training for the prevention of atrophy in rehabilitation. Time and money is saved for both institutions and individuals because exercises can be done at home. Fatigue can be eliminated, which makes this type of exercise desirable for persons who cannot place stress on the metabolic or circulatory processes.[21]

Rarick and Larsen did a study of two methods for building static muscular strength in relation to Muller's work. They refused two groups

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[21]Erich A. Muller, M. D., "The Regulation of Muscular Strength" Journal of the Association for Physical and Mental Rehabilitation, pp. 41-47, March, April, 1957.

composed of thirty postpubscent and twenty-seven prepubescent males. The former group performed one six second contraction daily using two-thirds maximum effort for five days a week. The latter group used a progressively greater number of six second daily bouts for five days a week with a eighty per cent tension. They found that while both groups gained in strength, the second group showed slightly greater strength gains. However, this gain was not highly significant.[22]

Charles P. Wolbers and Frank D. Sills performed an experiment using high school boys. The boys were pretested with four strength tests. After an eight week program of daily isometric exercises using two-thirds maximum contractions, the boys were retested. They had gained in all strength items except the Sargent Jump.[23] This lack of increase in explosive muscular power is contradictory to the results obtained by Professor Logan at the University of Southern California in his work with high jumper Bob Avant. Logan indicates that the inclusion of isometric exercises in Avant's training program explains Avant's sudden increase in muscular explosive power.[24]

Rarich and Larsen checked Muller's findings by testing postpubesent males. The results generally supported Muller's work in that brief periods

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[22]G. Lawrence Rarick and Gene L. Larsen, "Observations on Frequency and Intensity of Isometric Muscular Effort in Developing Static Muscular Strength in Post-Pubescent Males," Research Quarterly, 29: 333-341, October, 1958.

[23]Charles P. Wolbers and Frank D. Sills, "Development of Strength of High School Boys by Static Muscle Contractions," Research Quarterly, 27: 446-450, December, 1956.

[24]Op. Cit., Gilbert Rogin.

of isometric tension, one six second contraction daily at approximately two-thirds maximum tension, proved to be as effective for strength development as the more frequently repeated exercise bouts at higher tension levels. However, the latter method was somewhat superior in terms of strength retention. The resulting gains of strength were approximately five per cent per week.

Rarick and Larsen stated that Rasch and Morehouse reported insignificant gains in elbow flexion strength following a six week program of fifteen second contractions three days a week.

They also stated that Mathews and Kruze, in comparing isometric contractions with isotonic contractions on elbow flexor strength, concluded that isometric contractions led to greater strength although performed for only a fraction of the time that isotonic contractions during each training period.[25]

In experiments on two groups, one using isometric contractions and one using isotonic contractions, Darcus and Salter found that both training forms led to muscular strength increase. But in general, they found that isotonic contractions caused a greater per cent of increase than isometric contractions. Neither groups were told the results, but those using isotonic contractions could see their progress because they could lift heavier weights, whereas those using isometric contractions had no idea of the results. This could have been a motivating factor for the weight lifters. Isotonic contractions brought immediate results, whereas the increase from using isometric contractions did not appear until the second

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[25] Op. Cit., G. Lawrence Rarick and Gene L. Larsen.

week. Darcus and Salters believed the subjects did not correctly utilize the exercise at the beginning of the training period. They state that Asmussen found the same results in his experiments in 1949. Asmussen had stated that testing variations occurred at first as the subjects did not know when they had reached maximum strength. However, Asmussen suggests that isotonic contractions are not as effective as isometric contractions because they do not allow sufficient time for the muscles to reach their maximum tension.[26]

Dr. Steinhaus, in collaboration with Commander Charles D. Giauque, USNR, has developed thirteen isometric exercises called the "Commander Set--For Men and Women." These exercises are based on Muller's Experiments. They are performed without special equipment and each contraction is held for six seconds at maximum effort.[27]

Hunsicker and Montoye have written directions for chin ups and the vertical jump exercises.[28] These instructions were used by the author with certain modifications for testing the subjects.

Muller indicated the tests should not be given too frequently as they might affect the subjects training. He stated tests should be spaced over a number of weeks.[29] This factor was considered by the author and tests were given at four week intervals.

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[26]H. D. Darcus and Nancy Salter, "The Effects of Repeated Muscular Exertion of Muscular Strength," The Journal of Physiology, 129: 325-336, August 29, 1955.

[27]Arthur H. Steinhaus, Ph. D., M.P.E., How to Keep Fit and Like It (Chicago: The Dartnell Corporation, 1957), pp. 40-41.

[28]Paul A. Hunsicker and Henry J. Montoye, Applied Tests and Measurements in Physical Education, (New York: Prentice-Hall, Inc., 1953), pp. 75-77.

[29]Erich A. Muller, Op Cit.

Muller pretested the subjects to determine their status. Following this, a program of isometric exercises was given. Periodic tests and final tests were administered to determine progress. The test results were compared to indicate the effects on muscular strength.[30]

VIII. PSYCHOLOGICAL CONSIDERATION

Morehouse and Miller stated that certain psychological stimuli had an effect on performance.[31] G. T. Adamson stated that knowledge of results influences further individual performance.[32] Because of this, the author decided that the subjects should be made aware of all test results and that special environmental stimuli would be used throughout the experiment to stimulate training.

IX. SUMMARY

Chapter II has presented a survey of the literature which was used as a basis for this study. Chapter III presents the procedure for this study.

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[30] Erich A. Muller, Op. Cit.

[31] Op. Cit., Laurence E. Morehouse, Ph. D. and Augustus T. Miller, Jr., Ph. D.

[32] Op. Cit., G. T. Adamson.

CHAPTER III

PROCEDURE OF THE STUDY

I. SELECTION OF TEST ITEMS

In order to determine the effects of an isometric exercise program on muscular power and muscular endurance, the isotonic exercises used as a basis for measuring the effects of the program had to be determined. Selected were the vertical jump exercise to measure muscular power, and the chin up exercise to measure muscular endurance.

The muscle groups and actions involved in the two test items were analyzed so that isometric exercises effecting these muscle groups would be used. Only muscles having a major influence on these actions were noted.

The actions involved in the chinning exercise were flexion of the fingers, flexion of the elbow joint, extension of the shoulder joint depression and downward rotation of the scapula.[1] The major muscles used for flexion of the fingers were the flexor digitorum sublimus, flexor digitorum profundus and flexor pollicis longus; for flexion of the elbow joint were the biceps and brachioradialis; for extension of the shoulder joint were the posterior fibers of the deltoid, latissimus dorsi, teres major and long head of the triceps; for depression of the scapula were the latissimus dorsi and the pectoralis minor; for downward rotation of the scapula were

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[1] M. Gladys Scott, Analysis of Human Motion (New York. Appleton-Century-Crofts, Inc., 1942), pp. 290-291.

the pectoralis minor and the rhomboids. For adduction of the scapula were the rhomboids, and the trapezius.[2]

Consideration of the actions involved in the vertical jump exercise were limited to knee extension, hip extension and plantar flexion of the ankle. The major muscles used to cause leg extension were the vastus intermedius, vastus lateralis, vastus medialis, rectus femoris and the tensor-fascia lata; for hip extension were the long head of the biceps femoris, the semi-membranous, semi-tendinosus and the gluteus maximus, for plantar flexion were the gastrocnemius, soleus, tibialis posterior, peroneus longus, peroneus brevis, flexor hallucis longus and flexor digitorum longus.[3]

II. ISOMETRIC EXERCISES

Training exercises selected to develop muscular endurance were chosen on the basis of developing muscles equivalent to those exercised by the test items. Each subject was placed in a position so that the same muscle groups employed in chinning could be used during the isometric jump.

III. EQUIPMENT DEVISED FOR ISOMETRIC EXERCISES

The training exercises required special equipment to allow the individual to strain in the proper position without movement. Small

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[2] Ibid.

[3] Philip J. Rasch, Ph. D., F.A.C.S.M. and Roger K. Burke, Ph.D., F.A.C.S.M., Kinesiology and Applied Anatomy (Philadelphia: Lea and Febriger, 1959), pp. 224-227.

bars, tumbling safety belts with side rings, and chains were used for the isometric ups. They permitted the individual adjustments that were necessary to comply with varying body shapes and sizes. The subjects were anchored at the waist to allow for the static contraction and to allow freedom of contraction for the main muscle groups which were needed in the exercise. Each individual climbed the stall bars to the correct height to attain the proper angles in his elbow and shoulder joints. His body was anchored at the waist by a canvas tumbling safety belt which had two chains attached, one for each of the side rings. The chains had a snap on one end and eight multi-colored links on the other. Each chain was carried around a rung below the belt and held in proper position by the snap fastener on the end of the chain.

The equipment for leg extension exercise was designed to conform to the apparatus diagrammed and explained in Sports Illustrated.[4] Three uprights (four inches wide by four inches wide), which extended from the floor to the ceiling, were installed. These would allow for two working areas. Corresponding holes were drilled in the uprights at varying heights through which one inch steel shafts could be placed. Large cotter pins were placed in holes drilled in the steel shaft to prevent them from sliding out. Metal plates reinforced the wood surrounding the holes in the uprights. The center upright helped to support each of the two horizontal steel bars. A ten inch base board was placed under the three uprights to help anchor them and to serve as a base for the subjects.

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[4]Gilbert Rogin, "Get Strong Without Moving," Sports Illustrated, 15: 19-21, October 30, 1961.

IV. DETERMINATION OF ADJUSTMENTS

It was necessary to determine for each subject the position and angle for the actual adjustment of the apparatus to provide for the proper performance.

Three individuals buckled the safety belts around their waists at one time. Facing the stall bars, they climbed and grasped the top bar which was furthermost from the wall. Maintaining this grip, each subject moved up or down, supporting his weight with his feet on the rungs until the elbow and shoulder joints each formed a ninety degree angle. The angles were measured with a goniometer.

Chains were placed through the side rings of each belt. Each chain was circled around a rung below the level of the safety belt. The snap was fastened to one of the colored links. This adjustment was such that the subject's body was held in a position which maintained the ninety degree angle of the elbow and shoulder joints during the pull up exercise.

The rungs of the stall bars were numbered downward from one through seven, beginning with the third rung from the top. This was done to indicate which rung would be used for the chain attachment for each individual. The adjustments, rung number and chain link color were recorded on the individual record cards. This was done for all subjects and eliminated the necessity of measuring the angles of the elbow and shoulder joint before each subsequent exercise bout. An illustration of the recording form is shown on a sample record card--appendix B, page 67.

In the leg extension exercise, two students exercised at one time, each using one of the adjustable, horizontal bars. Each student wore a hard sponge shoulder pad with a hole in the center for his head. He placed his feet flat on the ten inch wide baseboard when straining. The bar was placed in that pair of holes in supporting posts which would provide a one hundred and fifteen degree angle in the knees of the subjects when the back was held erect.[5] The knee angle was measured with a goniometer. The subject's hands grasped the bar with an over-grip.[6]

The particular holes used on the uprights was noted as the indicated adjustment for each subject. Individual adjustments were recorded on the record cards.

V. DETERMINATION OF STATUS

To determine the muscular endurance of the upper extremities and shoulder girdle prior to the beginning of the eight week training program, each student did his maximum number of chin ups.

Equipment used included a horizontal ladder and magnesium carbonate (chalk).

Two students performed their chin ups simultaneously, one at each end of the horizontal ladder. The next person in each of the two lines counted and stopped any swinging motions. Chalk was rubbed on the hands

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[5] Aileen Carpenter, "A Study of Angles in the Measurement of the Leg Lift," Research Quarterly, IX: 70-72, October, 1938.

[6] R. T. DeWitt, "A Comparative Study of Three Types of Chinning Tests," Research Quarterly, 15: 249-251, October, 1944.

as each student stepped up for his exercise. The student started with an overgrip on the rung with the body fully extended. Each passed his chin over the ladder rung and lowered his body to the fully extended position on each chin up. Kicking or swinging was not permitted. Only complete chin ups were recorded.

The explosive muscular power of the lower extremities was determined through performance of the vertical jump.

Equipment used included a vertical jump blackboard, magnesium carbonate (chalk), a moist cloth and a high stool.

The students formed in one line. Each removed his shoes and stockings and rubbed his fingertips with chalk. The student stood with toes touching the wall with his heels on the floor. Keeping his heels on the floor, he reached up with arms extended and touched as far up the blackboard as he could and rubbed the chalk on the board with his fingertips. This gave his standing measurement. The height of the reach was recorded to the closest inch. This measurement was used as a basis for all three of his vertical jump tests of the program. The subject then turned sideways to the wall and from a crouched position, jumped, and with the fingertips of the hand nearest the wall, touched as high as he was able. This was repeated two more times. Before each jump, chalk was rubbed on the fingertips of the hand nearest the wall. The greatest height marked by the fingers was recorded to the closest inch along with the standing height measurement for each student. Two students took turns standing on the stool to wipe off chalk marks after each jump. Later on, the difference between the standing height and the greatest height measured was determined the closest inch.

VI. ADMINISTRATION OF ISOMETRIC EXERCISES

Authorities have indicated that to obtain the best results from an isometric exercise program, the exercises should be given once a day a minimum of five days per week. Accordingly, the subjects of this study performed the two isometric exercises once a day for five days per week. The students participated in the experiment as partial fulfillment of their physical education requirement program. Because Montana State University employs the quarter system, the exercise series was administered for only eight weeks. (Chapter II of this report summarizes other experiments which have used an eight week period with success). This period allowed for orientation, pretesting, periodic testing and final testing, along with the exercise schedule. To insure that the test activities did not influence training, only two tests were given after training was initiated, with four weeks separation between tests.[7]

For economy of time, the subjects were grouped according to their adjustments on the stall bars. For three of the four groups, three belts were chained to the bars at three different adjustments, each adjusted for approximately one third of the group. The belts remained chained while the entire group performed their exercise. This required only the buckling and unbuckling of the belt for each subject. In the fourth group there was no uniformity of adjustment. Each subject made his own predetermined adjustment as he took his turn.

The belt buckle was fastened in back of the subject. The student merely climbed the steel bars and grasped the top bar while as assistant

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[7] Ibid.

buckled the belt around his waist.

Three individuals exercised simultaneously. Each subject grasped the top bar with an overgrip. The students strained slightly with their legs to remove the slack from the chains. During the exercise, the feet were removed from the bars and each subject strained with maximum effort in the chin up position. They were timed for six seconds with a stop watch.[8] The signals were "Ready--Begin," and "Stop."

When the first three had completed the exercise, those next in line unbuckled the belts. This procedure was repeated on down the line. As soon as the students completed their isometric chin up exercise they moved to the horizontal bars.

The subject set the horizontal bar in a predetermined position so that when his shoulders strained against the bar, his knees would assume a one hundred and fifteen degree angle. After placing the hard sponge pad on his shoulders, the student stepped under the bar and performed the isometric exercise for six seconds. Five students were exercising at one time, three doing isometric chin ups and two isometric leg extension. Since the two exercise areas were adjacent, the preparatory signal, starting signal and signal to halt, controlled both exercises simultaneously.

VII. PSYCHOLOGICAL CONSIDERATION

Since psychological factors influence performance,[9] certain steps were taken to promote a positive attitude toward the isometric exercises

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[8] Ibid.

[9] G. T. Adamson, "Effects of Isometric and Isotonic Exercise on Elbow Flexor and Spine Extensor Muscle Groups," Health and Fitness in the Modern World, pp. 172-180, 1961.

and the test activities.

Only volunteer students were used for the study. Each student was assigned to read an article published in Sports Illustrated, October, 1961, on isometric exercises. This article illustrated types of isometric exercises and indicated that favorable results could be obtained.

A chart showing attendance and test results was posted after each test.

Frequently, verbal stimulus was given concerning the amount of bow each subject could produce in the steel horizontal bar, and a reminder was given to strain with maximum tension against the chains in the isometric chinning exercise.

Before each test, directions were read which were intended to stimulate performance as well as indicate directions.

VIII. ANALYSIS OF DATA

The results of the initial tests, periodic tests and final tests are presented for both the chin ups and vertical jump in chapters IV and V. Statistical comparisons are presented for the initial and final tests, for the initial and periodic tests, and for the periodic tests and final tests for the chin ups and the vertical jump.

The standard error of the difference was computed between correlated means was computed. Since this was considered as a closely related problem (the same group had been given the same two tests upon two occasions),

the formula $SE_d = \sqrt{SE_{m1}^2 + SE_{m2}^2 - 2r\ SE_{m1}\ SE_{m2}}$ was used.[10] The coefficient of correlation was computed using the Pearson Product moment method.

Since the group used for this experiment was fairly small (less than 50), the standard error of the mean was computed using the formula standard error of the mean equals the standard deviation over the square root of the number minus one.[11]

The means and standard deviations for the chin ups tests and the vertical jump tests were computed from the scatter-grams entered on the correlation charts after the coefficient of correlations were found for the relationships that existed between the scores made on the initial tests and periodic tests, the periodic tests and final tests, and the initial and final tests.

IX. SUMMARY

Chapter III has presented the procedure for the study which was based on the information presented in Chapter II. Chapter IV will present the findings of the tests which were given during the experiment.

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[10] Henry E. Garrett, Ph. D., Statistics in Psychology and Education, (New York: Longmans, Green and Co., 1960), pp. 218-227.

CHAPTER IV

FINDINGS OF THE STUDY

I. INTRODUCTION

This chapter presents the findings of the effects of isometric exercises on muscular endurance as measured by chin ups, and on muscular explosive power as measured by the vertical jump. Thirty-seven male college students attending Montana State University winter quarter 1962 volunteered to participate in the experiment as partial fulfillment of their physical education requirements. Four isotonic tests were given to measure the effects of the isometric exercise training program. Initial tests to determine each subject's maximum number of chin ups and maximal vertical jump ability was given and this information was recorded as the subject's status. After these tests, the subjects were given an eight week program of isometric exercises. Periodic tests were given at the end of four weeks of the exercise program and final tests were given at the end of eight weeks. The results of these tests are presented in the order in which the tests were given. The data from these three chin up tests are presented first, followed by the results of the three vertical jump tests.

II. RESULTS OF CHIN UP TESTS

Initial Test - The number of chin ups each subject could complete in the initial test was recorded to indicate the muscular endurance status

of the upper extremities.

The range for the initial test was from 0 to 10 chin ups. The mean was 5.70, and the standard error of the mean was .47. The standard deviation was 2.85.

Periodic test - The same kind of chinning test that was given for the initial test was given to the subjects after they had completed four weeks of the isometric exercise program. This test was given half way through the exercise program to determine the amount of change that had occurred.

The range for the periodic test was from 1 to 12 chin ups. The mean was 6.86 and the standard error of the mean was .50. The standard deviation was 3.00.

TABLE I

Test	R	M	SE_m	SD
Initial	0 - 10	5.70	.47	2.85
Periodic	1 - 12	6.86	.50	3.00

Results of Initial and Periodic Chinning Tests

(R = range, M = mean, SE_m = standard error of mean, SD = standard deviation.)

The range on the periodic test was one chin up greater than the range on the initial test. The mean was 1.16 chin ups higher on the periodic test than on the initial test. The standard deviation was .15 chin ups greater on the periodic test.

Final test - The final test for muscular endurance of the upper extremities, as measured by chin ups, was given at the end of the eight week isometric exercise program. The results of this test are presented in the same manner as were the results of the first two tests.

The range for the final test was from 1 to 14 chin ups. The mean was 8.00 and the standard error of the mean was .53. The standard deviation was 3.21.

TABLE II

Test	R	M	SE_m	SD
Periodic	1 - 12	6.86	.50	3.00
Final	1 - 14	8.00	.53	3.21

Results of periodic and final chinning tests.

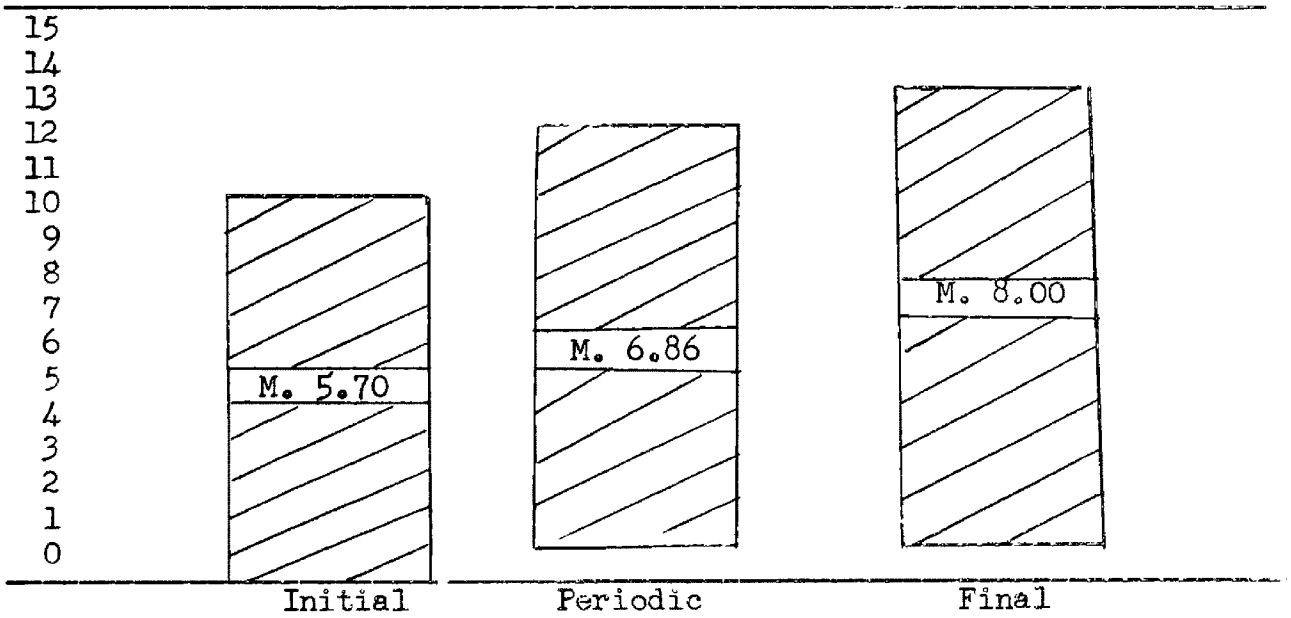
In comparing the results of the initial test with the final test, the final test shows the greatest range with a spread of one to fourteen chin ups. The mean on the final test of 8.00 was 2.30 chin ups greater than the mean of the initial test, which was an apparent improvement. The standard deviation was .36 greater in the final test.

TABLE III

Test	R	M	SE_m	SD
Initial	0 - 10	5.70	.47	2.85
Final	1 - 14	8.00	.53	3.21

Results of initial and final chinning tests

FIGURE 1



Range and mean for chinning tests

There was a progressive increase in the range for the three tests. The subjects on the lower end of the scale, doing the least number of chin ups (0-1), did not improve as much as those doing the greater number of chin ups (9-10) on the initial test. This caused the range to widen. The spread of scores did not reveal any gaps which might tend to distort these numbers and give misleading figures for the standard deviations.

A comparison of the means of the initial tests and periodic test shows the mean of the periodic test to be 1.16 chin ups above the mean of the initial test or about a 20 per cent increase. A comparison of the mean of the periodic test with the final test reveals the mean of the final test to be 1.14 higher or 17 per cent increase over the period test. In comparing the mean of the initial test with the mean of the final test was found to be 2.30 chin ups higher indicating an average increase of 40 per cent.

In order to establish the significance of the observed changes in the number of chin ups the subjects could perform after the training period, the coefficient of correlation, the actual difference between the means, the standard error of the difference and the critical ratio were computed. The confidence interval for this study was set at the .01 level.

Initial test and periodic test - The coefficient of correlation between the initial test and the period test was .92. The actual difference between the means of these two tests was the critical ratio was found to be 5.90, the observed difference of 1.16 was significant at the .01 level of confidence.

Periodic test and final test - In finding the confidence level between the periodic test and final test, the coefficient of correlation was found to be .94. The actual difference between the two means was 1.14, the standard error of the difference was .18 and the critical ratio was 6.25. This difference between means was significant at the .01 level of confidence.

Initial test and final test - In comparing the results between the initial test and final test, the coefficient of correlation was .91. The actual difference between the two means was 2.30. The standard error of the difference was .22. The critical ratio was found to be 10.36. The difference between the two was significant at the 0.1 level of confidence.

TABLE IV

Tests	r	D	SE_d	CR
Initial with periodic	.92	1.16	.20	5.90
Periodic with final	.94	1.14	.17	6.25
Initial with final	.91	2.30	.22	10.36

Comparison of three tests

(r = coefficient correlation, D = actual difference between means, SE_d = standard error of difference, CR = critical ratio.)

Per cent of subjects who increased in number of chin ups - An analysis was made to determine the per cent of subjects who increased in the number of chin ups they could perform, after the first four weeks of the training program, after the second four weeks of the training program (between the periodic test and final test) and for the total eight week training program.

At the end of the first four weeks of the training program 68 per cent of the subjects increased in the number of chin ups they could perform. In considering only the second four weeks of the training program, 73 per cent of the subjects showed an increase. Considering the entire eight

week training program, 97 per cent of the subjects showed an increase in the number of chin ups that they could perform.

Comparison of high group to low group - To find the effects of the training program in relation to the number of chin ups the individual could perform, a comparison was made between the low group, those subjects who performed 0 through 5 chin ups on the initial test, to those subjects in the high group who performed 6 through 10 chin ups on the initial test. Of the 37 subjects that were in the study, there were 20 subjects who did 0 through 5 chin ups and 17 subjects who did 6 through 10 chin ups. The total number of chin ups that the low group increased was 42. The total number of chin ups that the high group increased was 39. The increase of chin ups per subject was slightly greater in the higher group than in the lower group. The average increase per subject in the higher group was 2.3 chin ups, whereas the average increase per subject in the low group was 2.1 chin ups.

RESULTS OF VERTICAL JUMP

Initial test - The height that each subject could jump in the initial tests was recorded to indicate the muscular explosive power status of the lower extremities.

The range for the initial test was from 14 to 26 inches. The mean was 20.57, and the standard error of the mean was .50. The standard deviation was 2.98.

Periodic test - The same kind of vertical jump test that was given for the initial test was given to the subjects after they had completed

four weeks of the isometric exercise program. The test was given half way through the exercise program to determine the amount of change that had occurred in the four week period.

The range for the periodic test was 14 to 27 inches. The mean 20.43 inches and the standard error of the mean was .53. The standard deviation was 3.17.

TABLE V

Test	R	M	SE_m	SD
Initial	14 - 26	20.57	.50	2.98
Periodic	14 - 27	20.43	.53	3.17

Results of first two vertical jump tests

The range on the periodic test was one inch greater than the range on the initial test. The mean was .14 inches lower on the periodic test than on the initial tests. The standard deviation was .19 inches greater on the periodic test.

Final test - The final test for muscular explosive power of the lower extremities, as measured by the vertical jump, was given at the end of the eight week isometric exercise program. The range for the final test was from 15 to 27 inches. The mean was 20.84 and the standard error of the mean was .49. The standard deviation was 2.93.

TABLE VI

Test	R	M	SE_m	SD
Periodic	14 - 27	20.42	.53	3.17
Final	15 - 27	20.84	.49	2.93

Results of periodic and final vertical chinning tests

The range on the final test was one inch less than the range on the periodic test. The mean on the final test was .41 inches higher than the mean of the periodic test and the standard deviation was .24 inches less than the periodic test.

In comparing the results of the initial test with the final test, the final tests shows the same spread in number of inches. The mean on the final test was .27 inches higher than the mean of the initial test which did not seem to indicate any marked improvement. The standard error of the mean was .01 inches lower in the final test. The standard deviation was .05 lower in the final test.

TABLE VII

Test	R	M	SE_m	SD
Initial	14 - 26	20.57	.50	2.98
Final	15 - 27	20.84	.49	2.93

Results of initial and final vertical jump tests

In order to test the significance of changes in performance produced by the program in relation to the vertical jump, the single group

method was again used for computing the standard error of the difference between means.

In order to establish the significance of the observed change in the height the subjects could jump after the training period, the coefficient of correlation, the actual difference between the means, the standard error of the difference and the critical ratio were computed. The 1 percent level of confidence was used to determine the level of significance of differences between the initial test and periodic test, the period test and final test, and the initial test and final test.

Initial and periodic test - The coefficient of correlation between the initial test and the periodic test was .91. The actual difference between the first two means was .13 inches. The standard error of the difference was .21. The critical ratio was found to be .63 which ratio of 2.72 would have to exist to be significant at .01 level with this group.

Periodic test and final test - In finding the confidence level between the periodic test and final test, the coefficient of correlation was found to be .94. The actual difference between the two means was .40, the standard error of the difference was .18, and the critical ratio was 2.21. This did not indicate a significant change.

Initial test and final test - In comparing the results between the initial test and final test, the coefficient correlation was .94. The actual difference between the two means was .27. The standard error of the difference was .17. The critical ratio was found to be 1.57, which again did not indicate a significant change at the 1 per cent level of confidence.

TABLE VIII

Tests	R	D	SE_d	CR
Initial with periodic	.91	.13	.21	.63
Periodic with final	.94	.40	.18	2.21
Initial with final	.94	.27	.17	1.57

Comparison of three tests

Per cent of subjects who increased vertical jumping heights - An analysis was made to determine the per cent of subjects who increased in their jumping height after the first four weeks of the training program, after the second four weeks of the training program (between the periodic test and final test) and for the total eight week training program.

At the end of the first four weeks of the training program, 30 per cent of the subjects had increased the height they could jump. In the second four weeks of the training program, 35 per cent of the subjects showed an increase. Considering the entire eight week program, 15 per cent of the subjects showed an increase in the height they could jump.

Comparison of high group to low group - To find the effects of the training program in relation to the individuals' jumping height a comparison was made between the low group, those subjects who jumped 14 to 20 inches to those subjects in the high group who jumped 21 to 27 inches on the initial test. Of the 37 subjects that were in the study there were 20 subjects in the low group and 17 in the high group. The increase in jumping distance in the low group between the initial and

final test was 2 per cent. The increase for the high group between the initial and final test was .4 per cent.

SUMMARY

This chapter has presented the statistical findings of the study. These findings revealed that the mean score of the group of the chin ups had increased progressively on each test at approximately the same rate. The total increase in number of chin ups for the entire program was about 40 per cent. The observed difference in chinning ability was found to be significant at the .01 level of confidence.

The findings of the vertical jump tests revealed little change in the group's vertical jump ability. The mean increase between the initial and final test was .27 inches. This change was not found to be significant.

The following chapter will present the summary, conclusions and recommendations based on the findings from this chapter.

CHAPTER V

SUMMARY, CONCLUSIONS AND RECOMMENDATIONS

I. INTRODUCTION

In considering more economical and efficient ways of developing muscular strength, Dr. Muller stimulated interest in the use of isometric exercises in 1952. His experiments indicated that isometric exercises probably were the most economical and efficient for development of muscular strength. Other authorities have done similar experiments with isometric exercises in order to find their effects on muscular endurance and explosive power. At the time this report was written, there was still controversy over the effects of isometric exercises on muscular endurance and explosive power.

The purpose of this study was to determine the effects of isometric exercises upon (a) muscular endurance of the upper extremities and the shoulder girdle as measured by the ability to do chin ups, and (b) muscular explosive power of the legs as measured by the vertical jump. Thirty-seven male college students attending Montana State University winter quarter, 1962, volunteered to participate in the experiment as partial fulfillment for their physical education requirements.

In planning the program to develop muscular endurance and muscular explosive power as measured by chinning and the vertical jump respectively, isometric exercises relating to these two traits were selected.

An initial test of muscular endurance and muscular explosive power was given by having the students complete their maximum number of chin ups and maximal vertical jump.

A program of isometric exercises was administered over an eight week period to develop the main muscle groups involved in chinning and in the vertical jump. A periodic test of chinning and vertical jump ability was given at the end of four weeks and a final test was given at the end of eight weeks.

The significance of observed difference in performance was statistically determined.

II. SUMMARY

Chin ups - Muller used a training procedure which required one six second contraction daily for five days a week using maximum effort. The resulting mean increase in muscular strength was approximately 5 per cent per week or about a forty per cent increase after an eight week training period. The results of all but one isometric exercise experiment on muscular strength development reviewed by the author were found to be significant. In most studies the increase was significant at the .01 level of confidence.

For this study the author used daily six-second contraction using maximum effort for five days a week.

The results of the chin up tests in the author's experiment revealed a progressive increase in range. The subjects on the lower end of the scale, doing the least number of chin ups (0-1) did not improve as much as those doing the greatest number of chin ups (9-10) on the initial test.

This causes the range to widen. The greatest spread of scores occurred at the end of the last four weeks of the program. The spread of scores did not reveal any extreme gaps which might tend to distort the standard deviation.

The mean score of the group increased progressively on each of the last two tests at approximately the same rate. There was a 1.16 increase of the mean in the number of chin ups the group could perform after the first four week training period, and a 1.14 mean increase between the end of the first four week period and the end of the second four week period. The total increase of the mean performance of the group over the 8 week period was about 40 per cent or slightly over an average of 5 per cent week increase. This finding coincides with Muller's findings.

A slightly wider deviation of performance was observed in the results of the last two ability tests than was found in the initial test.

The standard deviation was .15 chin ups greater on the periodic test than on the initial test. The final test was .21 higher than the periodic test, and .36 greater than the first test. This increase in standard deviation coincides with the progressive increase in the spread of scores which occurred on the three tests. Those subjects on the upper end of the range had a greater increase in number of chin ups than did those on the lower end of the range.

The change in the number of chin ups the subjects could perform after the first four weeks of the training program was found to be significant at the .01 level of confidence. Since with the small group of 37 a critical ratio of 2.72 would be significant at the 1 per cent le-

of confidence, the obtained critical ratio of 5.90 was clearly significant. The effects of the second four week training program also proved to be significant at the .01 level of confidence with a critical ratio of 6.25. The critical ratio of 10.36 for the entire 8 week training program was highly significant at the .01 level of confidence indicated that a favorable result could be expected from an exercise program of this type given to similar subjects.

A comparison of the effects of isometric exercise on the low group (those doing 0-5 chin ups) with the high group (those doing 6-10 chin ups) revealed the number of chin ups increased per subject was greater in the higher than in the lower group. The average increase per subject in the high group was 2.3 chin ups, whereas the average increase per subject in the low group was 2.1 chin ups.

Vertical jump - Charles P. Wolbers and Frank D. Sills performed experiments with isometric exercises using high school boys for subjects. The boys were pretested with four isotonic strength tests, and then given an eight week isometric exercise training program. The subjects increased in all isotonic strength tests except the vertical jump. The investigators found that isometric contractions did not increase jumping heighth even though muscular strength increased on the average of 5 per cent a week.

In the author's study, the range of vertical jump test scores was fairly constant throughout the three tests. The range increased one inch on the periodic test, but was the same on the final test as it was on the initial test, namely 14 inches. There were no extreme gaps in the spread of scores.

The mean of the group performance revealed little change on the three tests. The mean of 20.43 inches for the periodic test was .13 inches lower than the mean of the initial test. The final was test mean of 20.84 inches, was .40 inches higher than the periodic and .27 inches higher than the initial test mean.

The standard deviation was approximately the same in the initial and final test (2.98 and 2.93). It was slightly higher on the periodic test than on the other two tests. The standard deviation increased on the periodic test as did the range.

The change in the mean score of the group for the three tests was not significant at the .01 level of confidence. The critical ratio for the initial and final test was 1.57. To be significant at the .01 confidence level there would have to be a critical ratio of 2.72.

CONCLUSIONS

1. Previous research reveals that isometric exercises cause a significant increase in muscular strength on the average of 5 per cent per week when administered daily, using six second, two-thirds maximal contractions. The author's study indicates that isometric exercises increase muscular endurance of the upper extremities and shoulder girdle muscles in doing chin ups on the average of 5 per cent per week for an eight week period when administered daily, using six second maximal contractions. Since muscular strength is an important aspect of muscular endurance, and since muscular endurance was increased during the eight week training period, it was assumed that muscular strength of the extremities was increased by the program of isometric exercises.

2. There is a progressive increase in muscular endurance of the upper extremities and shoulder girdles, as demonstrated by the ability to do chin ups, through a program of isometric exercises which relates directly to the amount of time the training is administered.

3. The average increase in chin ups for those subjects who were below the mean in the initial test and the average increase in chin ups for those subjects who were above the mean in the initial test were almost identical. The isometric exercise program did not tend to equalize the ability of the individual in the group, but tended to raise the group's ability as a whole while at the same time maintaining approximately the same spread of scores. On an average, those who were initially in the lower group of performance, increased the same number of chin ups after the 8 week training program as did those in the upper bracket of performance.

4. Isometric exercises, when six second contractions of maximal effort were administered daily for a period of eight weeks, did not cause any significant increase in muscular explosive power of the lower extremities for performing the vertical jump. In light of revelations made in the studies that muscular strength was increased through isometric training, the findings in this study, failed to indicate that increase in static muscular strength caused increase explosive muscular power as measured by the ability to perform the vertical jump.

RECOMMENDATIONS

The following recommendations are presented based upon the results of this study.

1. Further research should be carried out to find how long a period of time a group would continue to improve in the number of chin ups they could perform under an extended isometric training program.

2. Further research should be carried out to find what factors are involved in muscular explosive power.

3. It is recommended that this type of study be carried out with larger groups of subjects.

4. It is recommended that more specific measurements be made involving muscular strength along with the measurement of muscular explosive power and muscular endurance.

5. Further study should be made using selected groups such as low physical groups, or groups with high physical fitness indices.

6. It is recommended that isometric exercises be used as an economical method for development of muscular strength and endurance and as an economical method for continued maintenance of muscular strength and endurance.

7. Since the study revealed a marked increase in muscular endurance in the upper extremities, it could be assumed that equally beneficial effects should have been derived for the lower extremities. Since the vertical jump test did not reveal any improved performance, it is recommended that some other type of test be administered to measure the effects of an isometric exercise program.

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APPENDIXES

APPENDIX A

INSTRUCTIONS FOR CHIN UP AND VERTICAL JUMP TESTS

Experiments, similar to this on isometric exercises have been carried on throughout the United States, Canada, and Germany. These experiments have great implications. Isometric exercises are being used to help cut down on the injury rate in athletics and to develop strength which is an important part of fitness. It is being recommended for the rehabilitation of patients who have had muscular difficulties such as poliomyelitis and in correctives for certain deviations for limbs and joints. It is being recommended for heart patients since even the shortest contraction will increase strength, will not stimulate an increase in circulation and heart rate.

In order for the test results for this experiment to be correct and to give a true indication of what this type of exercise can do, we must put forth our maximum effort, or we will have performed this exercise training program for nothing.

Be sure that you perform each test in exactly the same way.

Chin up tests - Use an over grip on the bar. Don't swing or kick. Start from a fully extended position on each chin and pass the chin above the bar on each pull up. Only a complete chin will be counted.

Group one and two will work on the west end of the horizontal ladder. Group three and four will work on the east end of the ladder. Each will go to the table and pick up his card and get in a single line at the proper end of the ladder. As you take your turn, hand the card

to the student recorder and perform your chin ups.

Vertical jump - Form in one line and remove your shoes and stockings. When it is your turn rub chalk on your fingers and stand with your toes touching the wall, with your heels on the floor. Keeping your heels on the floor, reach up with your arms extended and touch as far up the blackboard as possible and rub the chalk on the board with your fingertips. This gives your standing measurement. This measurement will be used as a basis for all three tests of the program. You will then turn sideways to the wall and from a crouched position, jump and with the fingertips of the hand nearest the wall, touch as high as you are able. This will be repeated two more times. Before each jump, rub chalk on your fingertips of the hand nearest the wall. The greatest height marked by the fingers will be recorded to the closest inch along with the standing height measurement.

APPENDIX B

CHIN UP AND VERTICAL JUMP TESTS RESULTS

Case No	Chin up Tests			Vertical Jump Tests		
	1	2	3	1	2	3
1	10	10	12	18	17	17
2	1	2	2	19	18	19
3	3	4	5	19	18	20
4	2	4	4	14	14	15
5	8	8	9	19	19	19
6	9	9	9	20	21	20
7	8	8	11	23	24	22
8	7	7	9	25	26	26
9	10	11	11	22	22	22
10	5	8	7	22	21	22
11	6	9	9	17	18	18
12	4	6	6	16	16	18
13	2	2	4	20	20	20
14	8	8	9	23	22	21
15	7	6	8	18	21	21
16	10	10	12	22	23	23
17	9	10	11	24	24	24
18	1	1	2	16	17	17
19	9	11	11	25	24	25
20	7	7	9	21	22	22
21	3	4	6	23	21	21
22	8	10	11	24	24	26
23	5	5	6	23	23	23
24	4	5	6	20	15	19
25	8	11	12	26	27	27
26	3	3	4	19	19	19
27	5	7	10	20	20	20
28	9	11	14	25	24	25
29	4	5	7	20	20	20
30	4	7	8	17	17	17
31	4	6	9	24	24	24
32	4	5	6	24	23	24
33	10	12	12	21	22	21
34	6	10	12	18	17	17
35	0	1	1	17	17	16
36	4	6	7	19	20	21
37	4	5	5	18	16	18

Name John Doe Gp. No. 1 Class Soph. Age 20

College address Craig Hall Major English

P. E. activity fall quarter golf Present outside activity skiing

Home address Missoula, Montana

Sports in which you received letters and number of letters for each None

Test	No.C	V.J.
No. 1	5	20
No. 2	7	20
No. 3	10	29

Adjustments	WK	M	T	W	T	F	Group Rotation 8	8:15	8:30	8:45
Chins:	1						1	2	3	4
Bar No. 4	2						2	3	5	1
Chain Cyel	3						3	4	1	2
	4						4	1	2	3
	5						1	2	3	4
Leg Ex:	6						2	3	4	1
Post Hole 4	7						3	4	1	2
	8						4	1	2	3

SAMPLE OF SUBJECT'S RECORD CARD