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To the Graduate Council:

I am submitting herewith a thesis written by Arnold William Pedersen entitled "The Results of the Combined Isotonic-Isometric Execution Compared to the Isotonic Execution in Terms of Strength Development and Muscle Girth." I recommend that it be accepted for nine quarter hours of credit in partial fulfillment of the requirements for the degree of Master of Science, with a major in Physical Education.

Bernard Robinson
Major Professor

We have read this thesis and
recommend its acceptance:

Bill C. Wallace

Andrew J. Kozar

Accepted for the Council:

Hilton A. Smith
Dean of the Graduate School

THE RESULTS OF THE COMBINED ISOTONIC-ISOMETRIC

EXECUTION IN TERMS OF STRENGTH

DEVELOPMENT AND MUSCLE GIRTH

A Thesis

Presented to

the Graduate Council of

The University of Tennessee

In Partial Fulfillment

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by

Arnold William Pedersen

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CHAPTER I

INTRODUCTION

Although many studies have been made to determine a method of weight training which produces the greatest increases in muscle strength and muscle girth, the conclusions vary in theory and methodology.

Weight training has been subjected to much research in the past. Many of the researchers agree on a method of weight training which produces the best results. However, some advocate the use of isometric contractions as the most desirable method of gaining strength. Others state that isotonic exercise is the only logical way to increase one's strength. Still others say a combination of the two will produce optimum results if maximum strength and maximum development of muscle girth are the objectives. (A combination of the two means that after completing the isometrics the performer does the isotonics or vice-versa.)

All of the methods mentioned have proved to be of value; therefore, further probing into the subject appears to have come to a standstill.

I. THE PROBLEM

Purpose of the study. The purpose of this study was to determine whether a combination of isotonic-isometric movements is more

effective in producing strength gains and muscle girth than the standard rhythmic isotonic movements.

Statement of the problem. This research study was designed to compare resistance exercise, using an isotonic contraction combined with an isometric tensing contraction, with the rhythmic isotonic contraction and to determine their values in the development of strength and muscle girth.

CHAPTER II

REVIEW OF LITERATURE

A review of the literature exposed studies relative to isotonic exercise, isometric exercise, and isometric exercises versus isotonic exercises. These studies will be briefly reviewed in this chapter.

I. ISOTONIC EXERCISE

De Lorme conducted a study in 1946 to determine the best method of gaining strength through isotonic contractions. He found that low repetitions and heavy resistance exercises were most effective in building strength; also, if endurance was the objective, low resistance and high repetitions should be used.¹

In another study by De Lorme and Watkins in 1951, it was found that if maximum muscle strength and size are to be gained, the muscles should be subjected to strenuous exercising at regular intervals and with maximum effort.²

In 1961, Bready used thirty-four male subjects to determine the effects of heavy resistance weight training on the pattern of muscular development as shown by strength, girth, and endurance of the right

¹Thomas L. De Lorme, "Heavy Resistance Exercises," Archives of Physical Medicine, 27:607-630, October, 1946.

²Thomas L. De Lorme and Arthur L. Watkins, Progressive Resistance Exercise (New York: Appleton-Century-Crofts, Inc., 1951), p. 48.

elbow flexors. Results revealed that heavy resistance, low repetition exercise develops muscular strength and size.³

One hundred and fifty-nine college freshmen at The University of Tennessee were studied by Capen. The study was designed to compare four programs of heavy resistance exercises for the development of muscular strength. Results showed that the use of five executions with heavy resistance is probably most effective in developing muscular strength.⁴

In another study by Berger, the problem was to determine whether strength would develop more rapidly with fewer repetitions and heavier loads, with more repetitions and lighter loads, or with fewer or more sets. He concluded that, in general, three to five sets and five to ten repetitions or any combination of these would produce maximum strength increases most quickly.⁵

³Charles F. Bready, "A Study of the Effects of Heavy Resistance Training Upon the Pattern of Muscular Development as Indicated by Strength, Endurance, and Girth of the Right Elbow Flexors" (unpublished Master's thesis, University of Maryland, College Park, 1961).

⁴Edward K. Capen, "Study of Four Programs of Heavy Resistance Exercises for Development of Muscular Strength," Research Quarterly, 27:132-142, May, 1956.

⁵Richard Anthony Berger, "The Effect of Varied Weight Training Programs on Strength and Endurance" (unpublished Master's thesis, University of Illinois, Urbana, 1960).

In an early study Barney and Bangerter determined which of three methods of progressive resistance exercise produced greatest strength. Eighty male college students used a specific variation of progressive resistance exercise for an eight week period. All three methods showed significant strength increases, and one was not significantly better than another. The De Lorme-Watkins technique produced a significantly larger gain in anthropometric size as compared to traditional methods.⁶

II. ISOMETRIC EXERCISE

The comparative effects of isometric and dynamic weight-training exercises on strength and on the speed of execution of single movements was investigated by Chui. A cable-tensiometer was used to obtain the strength scores. He concluded that gains in strength made by use of the isometric contraction method are not greater ($p = .05$) than gains made by the use of the dynamic contraction methods in weight training.⁷

Royce did a review of literature to determine the value of isometric training methods in producing strength gains. He found that, according to Hettinger and Muller, the larger the ratio between static load and initial maximal force the greater the increase in strength. Also, he discovered that contractions below a certain force level have

⁶Vernon S. Barney and Blauer L. Bangerter, "Comparison of Three Programs of Progressive Resistance Exercise," Research Quarterly, 32:138-146, April, 1961.

⁷Edward F. Chui, "Effects of Isometric and Dynamic Weight Training Exercises Upon Strength and Speed of Movement," Research Quarterly, 35:246-257, October, 1964.

no training effect. Repeating a short maximal contraction several times a day does not increase the training effect.⁸

Rich, Ball and Wallis used sixty-three male college students from ages 18 to 23 to determine the effects of a single ten-second-bout isometric program for a period of six weeks. Each subject trained three times a week. Each effort was to be a maximum output. The other group trained used the same training method, but only exerted two-thirds of the maximum effort. The researchers found that the first group, which trained with maximum effort, gained significantly in both pushing and pulling strength, while Group II showed no significant gain.⁹

Bender, Kaplan, and Johnson reviewed the studies of isometrics and critiqued the material. Most of their conclusions were based on their own studies. They state that the greatest value in isometrics, so far, has been in measuring strength. The isometric contraction must be controlled if proper strength development is to be gained. Isometric exercises are not the whole answer to the conditioning needs of most individuals. An isometric conditioning program using gross exercises is often more detrimental than beneficial. For the best results,

⁸Joseph Royce, "Re-Evaluation of Isometric Training Methods and Results, A Must," Research Quarterly, 35:215-216, May, 1964.

⁹George Q. Rich, Ferry R. Ball, and Earl L. Wallis, "Effects of Isometric Training on Strength and Transfer of Effect to Untrained Antagonists," The Journal of Sports Medicine and Physical Fitness, 4:217, December, 1964.

isometric exercises should be accompanied by appropriate isotonic exercises. No easy work can replace hard work.¹⁰

Berger also reviewed the literature in the field of isometrics and came up with these conclusions. Isometric training will not increase muscular girth significantly. Studies show conflicting evidence concerning whether or not maximum contraction is required. A contraction of four to six seconds is better than a one-second contraction. Relatively few studies have compared the effects of static and dynamic training on specific areas of motor performance; however, one study has shown that vertical jumping ability is improved significantly more by weight training than by isometric training.¹¹

III. ISOMETRICS VERSUS ISOTONICS

A study was conducted in 1955 at Pennsylvania State University by Melvin M. Lorback. In his study he compared the effectiveness of strength training, using short periods of static contractions, with standard weight training procedures. He found that both were beneficial in producing strength and muscle girth and that there was no significant

¹⁰Jay A. Bender, Harold M. Kaplan, and Alex J. Johnson, "Isometrics A Critique of Faddism Versus Facts," Journal of Health, Physical Education and Recreation, 34:21-24, May, 1963.

¹¹Richard A. Berger, "Effects of Isometric Training," The Physical Educator, 22:81, May, 1965.

difference in their gains.¹²

Kruse compared the relationship between three six-second isometric contractions and isotonic contractions to exhaustion for an exercise period of four weeks. He found only a .60 pound difference, which is not statistically significant, in favor of the isotonic method of exercising.¹³

Bender and Kaplan used one hundred and twenty-eight young males to determine whether dynamic (isotonic) strength may be evaluated isometrically. A measurable task (pull-ups) was selected. Results indicated that the strength necessary to perform a dynamic movement can be measured by isometric techniques. They also indicated that failure in a given movement may be caused by a lack of strength only at a specific region in the range of motion and that some external assistance in passing through that region can produce success.¹⁴

In a seven-week study done at the University of Maryland, Morgan wanted to determine the best way to develop muscular strength and size.

¹²Melvin M. Lorback, "A Study Comparing the Effectiveness of Short Periods of Static Contractions to Standard Weight Training Procedures in the Development of Strength and Muscle Girth" (unpublished Master's thesis, Pennsylvania State University, University Park, 1955).

¹³Robert K. Kruse, "The Effects of Varying Frequencies of Training Sessions Upon the Strength of the Elbow Flexor Muscle Group" (unpublished Master's thesis, Springfield, Massachusetts, 1956).

¹⁴Jay A. Bender and Harold M. Kaplan, "Determination of Success on Failure in Dynamic (Isotonic) Movements by Isometric Methods," Research Quarterly, 37:3-8, March, 1966.

The subjects were divided into three groups. Two groups used heavy resistance training, one used phasic weight training methods, and the other group used static weight training methods. The third group had no activity. Morgan concluded that heavy resistance, low repetition exercise was the best way to develop muscular strength and size. However, the static and phasic exercises were both of great value in developing strength.¹⁵

In 1962, McConnell conducted a study comparing three types of training. One group used standard weight training methods, another group used dynamic tension and the third did nothing. Eight strength tests were used after a nine month period of exercising. Results for all tests showed that the mean changes for the weight trained group were significantly greater than the mean changes for the dynamic tension group, suggesting that the weight trained group was superior.¹⁶

McConnell also noted that the dynamic tension group showed less interest in their activities than the weight trained group.¹⁷

Berger's study was designed to determine the kind of training

¹⁵William P. Morgan, "The Effectiveness of Static Exercises as Opposed to Phasic Exercise for Increasing Muscular Strength and Size" (unpublished Master's thesis, University of Maryland, College Park, 1958).

¹⁶Sidney D. McConnell, "The Effects of Weight Training Compared With the Effects of Dynamic Tension on the Development of Strength and Motor Ability" (unpublished Master's thesis, State University of Iowa, Iowa City, 1962).

¹⁷Ibid, p. 47.

resulting in the most rapid strength increase. Fifty-seven male college students were trained statically three times weekly for twelve weeks. Six to eight-second maximum contractions were used in two positions of the bench press. The improvement in strength in the statically trained group was compared to the improvement made by nine groups of subjects who trained dynamically with various bouts and repetitions for the same length of time.

Results showed that training statically for six to eight seconds at two different positions is more effective for increasing muscular strength than training dynamically with two repetitions for two bouts, but not as effective as six repetitions for three bouts.¹⁸

Lester Brod made a comparison of two programs of training in 1963. His goal was to determine whether either an isotonic or an isometric training program alone, or a combined isometric-isotonic training program would produce a greater improvement in strength. The subjects were tested before and after a program of seven weeks. Group A used weights with four sets and three to five repetitions. Group B engaged in a combined isotonic-isometric training program using two sets of isotonic and two six-second maximal contractions. Group C used an isometric training program consisting of four six-second maximal contractions. Brod's conclusion was that the isotonic-isometric training routine was more effective in producing strength

¹⁸Richard A. Berger, "Comparison Between Static Training and Various Dynamic Training Programs," Research Quarterly, 34:131-134, May, 1963.

than either an isotonic or an isometric routine.¹⁹

Again in 1963, Grueninger made a study to determine the effects of a twelve week training program on static and dynamic strength. The training methods involved the use of progressive resistance exercise in one group and an isometric method consisting of three ten-second contractions in seven basic positions in the other group. At the end of the training period, the isotonic group was significantly stronger in dynamic strength; however, both groups showed considerable strength increases.²⁰

¹⁹Lester J. Brod, "Effects of Various Isotonic and Isometric Training Programs of Pressing Strength" (unpublished Master's thesis, University of Illinois, Urbana, 1963).

²⁰Robert W. Grueninger, "The Contributions of Isometric and Isotonic Contractions to the Development of Static and Dynamic Strength in Young Boys" (unpublished Master's thesis, University of Illinois, Urbana, 1963).

CHAPTER III

PROCEDURES

The purpose of this chapter is to explain how the subjects were selected and how the tests were administered, to describe the tests and measurements, and to explain the exercise program of the experimental and control groups.

I. SELECTION OF SUBJECTS

The subjects used in this study were fifty-six freshmen and sophomore men enrolled in two weight-training classes at The University of Tennessee. All of the subjects elected weight training as part of their physical education requirements. Both classes were taught by the investigator. The participants in the control and experimental groups were picked at random.

II. TESTS AND MEASUREMENTS

A strength test and anthropometric measurements were used as the basis for collecting data on the subjects. Tests and measurements were conducted at the beginning and at the end of the nine-week session of the Spring Quarter. The testing took place the third week in March and the last week in May. All tests and measurements for each participant were administered personally by the writer.

Strength Tests

Upper arm flexion. The upper arm flexion or bicep strength was tested with a cable-tensiometer. The testee stood on a wooden platform. An eight-inch long airplane cable was attached to the platform by the use of a chain to which was linked a hook type clamp. This allowed adjustments for subjects of various heights. The other end of the cable was enclosed by a piece of half-inch pipe to provide a suitable handle for the subject. The arm angle was determined by the use of the goniometer, and the chain was placed in the proper link. The tensiometer was then attached to the cable and read as the student flexed his arm. Before testing, each participant was informed of the necessity of using only the bicep muscles, not the shoulders. He was also asked to avoid rising on his toes. The reliability of this testing method has been analyzed and the results produced a correlation coefficient of .923.

Upper arm extension. To test the upper arm extension, the subject took a position on his back on top of a padded testing table. The table was placed so that the head of the table was against the wall and the testee faced away from the wall. The same cable and chain combination used for upper arm flexion was used here, only this time it was attached to the wall behind the subject. Lying on his back, the testee raised his forearm, fingers pointing toward the ceiling, and gripped the pipe handle. Again the proper arm angle was set by use of the goniometer, and the proper link was chosen and

inserted in the hook. Another participant held the testee's feet to prevent him from pulling himself backward. As the cable tensiometer was placed on the cable, the testee extended his forearm using only the tricep muscles. The testee kept his forearm on his stomach and his shoulders flat on the table to assure the use of only the tricep muscles.¹

In both the upper arm extension and flexion tests, readings were taken three times on different days and the mean was recorded to assure accuracy.²

Anthropometric Measurements

Upper arm circumference. This measurement was taken with the arm fully relaxed and hanging normally at the side. A measurement of five inches from the acromion process was marked with a pen. At that point the circumference of the arm was measured.³ The tape was held firmly enough around the arm to avoid any slack in the tape.

¹Clarke H. Houison, Earl C. Elkins, G. M. Martin, and K. C. Wakim, "Relationships Between Body Positions and the Application of Muscle Power to Movement of the Joint," Archives of Physical Medicine, 31:81-89, February, 1950.

²Lynn W. McCraw and Byron N. McClenney, "Reliability of Fitness Strength Tests," Research Quarterly, 36:289-294, October, 1965.

³M. Gladys Scott and Ester French, Measurement and Evaluation in Physical Education (Dubuque: Wm. C. Brown Company Publishers, 1959), p. 251.

III. THE PROGRAM

Both groups in the study trained two times per week for nine weeks. Each session was forty minutes long. The students' adherence to the program was assured by the investigator who taught both classes.

Control Group

All the students in the control group did standing tricep extensions and standard arm curls using four sets of six repetitions. These progressive resistance exercises were executed in the standard rhythmical way. The amount of resistance allowed each subject just four sets of six repetitions and no more. When he could do more he added more weight.

Experimental Group

This group used the same procedure as far as repetitions and sets were concerned; however, the method was altered. Instead of executing one repetition and immediately going on to the next, the participants, after curling or extending the weight, held the weight in the completed position, then tensed and exerted pressure against the weight at that point for a count of three seconds. Then the subject began the next repetition. This tensing exertion was made after each repetition to reduce to a minimum the flow of blood from the muscle.

CHAPTER IV

ANALYSIS OF DATA

Upon completion of the final testing, the data were processed to determine whether the measurements taken at the beginning of the study were significantly different from those taken at the end of the study. This information was then used to determine the differences between the group using standard isotonic exercises and the group using the combined isometric-isotonic exercises. Strength tests and anthropometric measurements were taken. In order to compare the mean gains the t-statistic was used.¹ Levels of confidence were obtained from Fisher's and Yates' Statistical Tables for Biological, Agricultural and Medical Research.² The 5 per cent level of confidence was used to determine what was statistically significant in this study.

I. ANALYSIS OF STRENGTH SCORES

The scores of the standard isotonic trained group and the results of the testing are summarized in Table I. The scores of the

¹J. P. Guilford, Fundamental Statistics in Psychology and Education (second edition; New York: McGraw-Hill Book Company, Inc., 1950), p. 228.

²Ronald A. Fisher and Frank Yates, Statistical Tables for Biological, Agricultural and Medical Research (third edition; London: Oliver and Boyd Ltd., 1948), p. 30.

TABLE I
ANALYSIS OF STRENGTH TESTS FOR THE
ISOTONIC TRAINED GROUP

Test Item	Initial Mean	Final Mean	Mean Difference	t
Right Arm Flexion (Bicep)	44.9	52.4	7.6	9.21 [*]
Right Arm Extension (Tricep)	31.3	36.1	4.9	8.7 [*]

^{*}Indicates statistical significance at the 5 per cent level of confidence.

combined isometric-isotonic trained group and the results of the testing are summarized in Table II. The results of the strength scores between the two groups are found in Table III. All three tables illustrate initial means, final means, mean differences, and the t-statistic. Those mean differences which are significant at the less than 5 per cent levels of confidence are indicated by an asterisk.

Right Bicep Flexion

The isotonically trained group had an initial mean of 44.9 pounds for right bicep flexion. The final mean was 52.4 pounds. This produced a mean difference of 7.6 with a t of 9.21 which was statistically significant at the 5 per cent level of confidence.

The isometrically-isotonically trained group had an initial mean of 47.8 pounds for right bicep flexion. The final mean was 57.6 pounds. This produced a mean difference of 9.4 with a t of 11.39 which was statistically significant at the 5 per cent level of confidence.

The mean deviation of the right bicep flexion test of the isotonic group was 9.4 pounds. The mean deviation of right bicep flexion test of the isometric-isotonic group was 7.6 pounds. This produced a t of 1.52 which was not statistically significant at the 5 per cent level of confidence.

Right Tricep Extension

The isotonically trained group had an initial mean of 31.3 pounds for the right tricep extension. The final mean was 36.1 pounds. This

TABLE II
ANALYSIS OF STRENGTH TESTS FOR THE
ISOTONIC-ISOMETRIC TRAINED GROUP

Test Item	Initial Mean	Final Mean	Mean Difference	t
Right Arm Flexion (Biceps)	47.8	57.6	9.4	11.39*
Right Arm Extension (Triceps)	32.7	39.5	6.8	7.96*

*Indicates statistical significance at the 5 per cent level of confidence.

TABLE III
 COMPARISON OF STRENGTH GAINS BETWEEN
 THE ISOTONIC TRAINED GROUP AND THE
 ISOTONIC-ISOMETRIC TRAINED GROUP

Test Item	M_D	M_D	Mean Difference	t
	Isotonic Trained Group	Isometric-Isotonic Trained Group		
Right Arm Flexion (Bicep)	9.4	7.6	1.8	1.52
Right Arm Extension (Tricep)	4.9	6.8	1.9	1.87

produced a mean difference of 4.9 with a t of 8.7 which was statistically significant at the 5 per cent level of confidence.

The isototonically-isometrically trained group had an initial mean of 32.7 pounds for the right tricep extension. The final mean was 39.5 pounds. This produced a mean difference of 6.8 which was statistically significant at the 5 per cent level of confidence.

The mean deviation of the right tricep extension test of the isototonically trained group was 4.9 pounds. The mean deviation of the right tricep extension test for the isometrically-isotonically trained group was 6.8 pounds. This produced a t of 1.87 which was not statistically significant at the 5 per cent level of confidence.

II. ANALYSIS OF ANTHROPOMETRIC MEASUREMENTS

The anthropometric measurements of the standard isototonically trained group and the results of the testing are summarized in Table IV. The anthropometric measurements of the combined isometrically-isotonically trained group and the results of the testing are summarized in Table V. A comparison of the anthropometric measurements of the two groups is found in Table VI.

Right Upper Arm Circumference

The measurement of the upper right arm of the isototonically trained group revealed a mean of 12.250 inches. The final mean was 12.413 inches. This produced a mean difference of 1.63 with a t of 2.62 which was statistically significant at the 5 per cent level of

TABLE IV
ANALYSIS OF THE ANTHROPOMETRIC MEASUREMENTS
FOR THE ISOTONIC TRAINED GROUP

Test Item	Initial Mean	Final Mean	Mean Difference	t
Right Biceps	12.250	12.413	1.63	2.62 *

*Indicates statistical significance at the 5 per cent level of confidence.

TABLE V
ANALYSIS OF THE ANTHROPOMETRIC MEASUREMENTS FOR THE
ISOMETRIC-ISOTONIC TRAINED GROUP

Test Item	Initial Mean	Final Mean	Mean Difference	t
Right Biceps	12.870	13.057	1.875	4.06*

*Indicates statistical significance at the 5 per cent level of confidence.

TABLE VI
COMPARISON OF THE GAINS IN ANTHROPOMETRIC MEASUREMENTS
BETWEEN THE ISOTONIC TRAINED GROUP AND THE
ISOMETRIC-ISOTONIC TRAINED GROUP

Test Item	M_D	M_D	Mean Difference	t
	Isotonic Trained Group	Isometric-Isotonic Trained Group		
Upper Arm (Right)	1.63	1.8750	.2450	6.81*

*Indicates statistical significance at the 5 per cent level of confidence.

confidence.

The measurement of the upper right arm of the isometrically-isotonically trained group revealed a mean of 12.870 inches. The final mean was 13.057 inches. This produced a mean difference of 1.875 with a t of 4.06 which was statistically significant at the 5 per cent level of confidence.

The mean deviation of the right upper arm circumference measurements for the isotonically trained group was 1.63. The mean deviation of the isometrically-isotonically trained group was 1.8750. This produced a t of 6.81 which was statistically significant at the 5 per cent level of confidence.

CHAPTER V

SUMMARY AND CONCLUSIONS

The purpose of this study was to compare two different weight training programs and to determine which would prove superior for increasing strength and muscle girth of the bicep and tricep muscles. Strength tests and anthropometric measurements were taken, and the gains of each group were statistically compared to determine which program was superior.

I. SUMMARY

Although both groups showed statistically significant t scores at the 5 per cent level of confidence in strength gains, this evidence can only suggest that both methods of weight training will increase strength. However, to what degree they will increase strength is not reflected by the t scores which were unusually high. Although both testing methods have been proven valid, other factors may have contributed to the overall high t scores for strength increases.

Both bicep strength and tricep strength showed increases at the 5 per cent level of confidence for both groups in the study. Comparison of strength scores between the two groups did not show a significant increase at the 5 per cent level of confidence.

For the anthropometric measurements, both groups showed a statistically significant increase at the 5 per cent level of confidence.

In a comparison of the gains for the isotonically trained group and the isometrically-isotonically trained group, the anthropometric measures were statistically significant at the 5 per cent level of confidence and at the 1 per cent level of confidence. This difference was due to the larger measurement gains by the isometrically-isotonically trained group and may have been a direct result of restricting the flow of blood out of the muscle by tensing.

II. CONCLUSIONS

The following conclusions were drawn from the results of this study:

1. Both the isotonic-isometric and the isotonic groups had gained significantly in strength at the end of the program.
2. Both methods are beneficial for increasing strength and one method is as effective as the other.
3. Both groups had significant gains in anthropometric measurements or arm musculature.
4. The combined isometric-isotonic tensing method produced a significant increase in arm musculature.
5. The isotonic method produced an increase in arm musculature; however, the combined isometric-isotonic tensing method produced a greater over-all increase in arm musculature.

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APPENDICES

APPENDIX A

TABLE VII
 RAW SCORES OF THE RIGHT ARM FLEXION TESTS
 FOR THE ISOTONIC TRAINED GROUP*

Subjects	Initial	Final	Difference
1	54	58	4
2	46	58	12
3	50	58	8
4	45	55	10
5	43	54	11
6	44	48	4
7	49	56	7
8	45	57	12
9	45	52	7
10	44	46	2
11	40	53	13
12	48	58	10
13	58	63	5
14	46	50	4
15	35	45	10
16	52	60	8
17	39	52	13
18	44	50	6
19	40	46	6
20	46	52	6
21	46	56	10
22	49	56	7
23	29	43	14
24	52	48	-4
25	40	50	10
26	38	40	2

*Arm strength tests were recorded in pounds.

TABLE VIII

RAW SCORES OF THE RIGHT ARM FLEXION TESTS
FOR THE ISOTONIC-ISOMETRIC TRAINED GROUP*

Subjects	Initial	Final	Difference
1	56	65	9
2	48	54	6
3	46	54	8
4	36	58	22
5	42	52	10
6	45	54	9
7	44	52	8
8	62	77	15
9	43	54	11
10	70	78	8
11	54	58	4
12	56	60	4
13	44	56	12
14	54	63	9
15	46	58	12
16	52	53	1
17	30	47	17
18	44	53	9
19	45	54	9
20	39	52	13
21	43	54	11
22	45	52	7
23	54	61	7
24	61	70	9
25	56	58	2
26	29	52	13

*Arm strength tests were recorded in pounds.

TABLE IX

RAW SCORES OF THE RIGHT ARM EXTENSION
TESTS FOR THE ISOTONIC TRAINED GROUP*

Subjects	Initial	Final	Difference
1	39	45	6
2	30	34	4
3	42	54	12
4	32	35	3
5	28	35	7
6	26	35	9
7	30	38	8
8	40	46	6
9	28	34	6
10	26	34	8
11	30	35	5
12	36	41	5
13	40	43	3
14	29	34	5
15	23	30	7
16	36	38	2
17	32	35	3
18	28	31	3
19	26	32	6
20	34	35	1
21	38	40	2
22	38	40	2
23	23	31	8
24	28	30	2
25	28	28	0
26	26	30	4

*Arm strength tests were recorded in pounds.

TABLE X

RAW SCORES OF THE RIGHT ARM EXTENSION TESTS FOR THE
ISOTONIC-ISOMETRIC TRAINED GROUP*

Subjects	Initial	Final	Difference
1	42	52	10
2	29	38	9
3	36	38	2
4	32	38	6
5	24	28	4
6	29	32	3
7	36	41	5
8	36	54	18
9	25	35	10
10	45	54	9
11	40	52	12
12	32	35	3
13	29	38	9
14	32	38	6
15	38	54	16
16	32	32	0
17	18	25	7
18	26	35	9
19	32	41	9
20	32	37	5
21	22	30	8
22	26	32	6
23	35	38	3
24	59	59	0
25	29	32	3
26	35	41	6

*Arm strength tests were recorded in pounds.

TABLE XI

ANTHROPOMETRIC MEASUREMENTS OF THE RIGHT BICEPS FOR
THE ISOTONIC TRAINED GROUP MEASURED IN INCHES

Subjects	Initial	Final	Difference
1	13.5	13.375	-.125
2	13.75	13.75	0.0
3	12.875	13.625	.75
4	11.75	12.25	.5
5	12.	12.375	.375
6	11.	11.5	0.0
7	13	13.25	.25
8	13	13	0.0
9	12	11.75	-.25
10	11.5	11.75	.25
11	12.125	12.5	.375
12	12.5	12.75	.25
13	13.5	13.75	.25
14	12.25	12.25	0.0
15	10.5	10.75	.25
16	13.875	13.875	0.0
17	12.25	12.75	.5
18	12	12	0.0
19	11.875	12	.125
20	11.875	12.5	.625
21	12.25	12.5	.25
22	11.75	12	.25
23	11.5	12	.5
24	12.75	11.875	-.875
25	11.75	11.875	.125
26	10.875	10.75	-.125

TABLE XII

ANTHROPOMETRIC MEASUREMENTS OF THE RIGHT BICEPS FOR THE
ISOTONIC-ISOMETRIC TRAINED GROUP MEASURED IN INCHES

Subjects	Initial	Final	Difference
1	15	15	0.0
2	13.5	13.75	.25
3	11.25	11.5	.25
4	11.75	12	.25
5	11.75	11.75	0.0
6	11.75	11.75	0.0
7	14	14.125	.125
8	12.625	13.125	.5
9	12.5	12.75	.25
10	14.5	14.875	.375
11	14.5	14.75	.25
12	14.25	14.875	.625
13	12.25	12.375	-.125
14	13.75	13.75	0.0
15	13.75	14.25	.5
16	11.5	12	.5
17	10.625	11	.375
18	12.5	12.5	0.0
19	13	13	0.0
20	11.75	11.5	-.25
21	12	12.25	.25
22	12.875	13	.125
23	13.25	13	-.25
24	15.875	16	.125
25	11.25	11.75	.5
26	12.625	12.875	.25

APPENDIX B

FORMULAE USED FOR COMPUTING
STATISTICAL DATA

The formula used for determining the significance of a difference between the means of a related measure was the following:¹

$$t = \frac{\bar{X} - \mu}{S_m}$$

The formula used for predicting the level of confidence at which the differences between the mean of the groups were significant is show below:²

$$S_d = \sqrt{\frac{(N_1 - 1) S_1^2 + (N_2 - 1) S_2^2}{N_1 + N_2 - 2}} \cdot \sqrt{\frac{1}{N_1} + \frac{1}{N_2}}$$

¹George Weinberg, and John Schumaker, "Statistics, An Intuitive Approach," (Belmont, California: Wadsworth Publishing Co., Inc., 1965), p. 326.

²Weinberg, loc. cit.