# THE EFFECTS OF ISOMETRIC, ISOTONIC, AND ISOKINETIC TRAINING PROGRAMS UPON PUSH-UP ACHIEVEMENT IN HIGH SCHOOL BOYS

Thesis for the Degree of M. S.
MICHIGAN STATE UNIVERSITY
FRANK LEE DEITRICK
1972

ABSTRACT

THE EFFECTS OF ISOMETRIC, ISOTONIC, AND ISOKINETIC TRAINING PROGRAMS UPON PUSH-UP ACHIEVEMENT IN HIGH SCHOOL BOYS

By

Frank Lee Deitrick

The purpose of the study was to examine the effects of isometric, isotonic, and isokinetic exercise under controlled conditions on the push-up achievement of high school boys. Since the isokinetic exerciser utilizes a constant rate, the effects of varying rates upon push-up performance was also examined. Twenty-eight subjects were randomly selected from those enrolled in a sixth hour physical education class at Sexton High School (Lansing, Michigan). The subjects were randomly assigned to four treatment groups--control, isometric, isotonic, and isokinetic. Each subject was pretested for the number of complete push-ups which could be achieved at three different push-up rates. A pilot study determined the push-up rates that were used in the study. The hypothesis of the author was that there was no significant difference between the gain scores of the treatment groups. A five week training program was initiated with the control group attending the regular physical education class daily and the experimental groups training isometrically, isotonically, and isokinetically on the bench press exercise. Each experimental group trained three days a week and attended the regular physical education class the other two days. After the

training program, each subject was post-tested for the number of complete push-ups which could be achieved at the three push-up rates. The design of the study was a 4x3, 2-way Analysis of Variance of gain scores with unequal n. The results of the ANOVA of gain scores indicated there was a significant treatment effect at the .03 level, but neither the push-up rate effect nor the interactions were significant. However, in post hoc examination of the treatment effect, neither the Scheffé nor the less rigorous Duncan or Student Newman Keul multiple comparison tests could detect a significance at the .05 level between treatments. Thus, the conclusion of the study necessarily must be limited to the significant differences between the four treatment groups with no further definition.

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By

Frank Lee Deitrick

A THESIS

Submitted to
Michigan State University
in partial fulfillment of the requirements
for the degree of

MASTER OF SCIENCE

Department of Health, Physical Education and Recreation

1972

Dedication

To Katherine Mary and Tracy
Mac Leod Deitrick

## ACKNOWLEDGMENTS

The author wishes to express his appreciation to professors Dr. Wayne Van Huss and Dr. William Heusner for their professional assistance, to Thomas Gilliam for his guidance with the analysis, and to John Collins whose physical education class was used in the research.

## FOREWORD

This thesis is atypical from the conventional technique generally employed to report research data in a thesis format. The data are presented as they would appear in a professional science journal describing research.

This change provides a more concise, scientific presentation of the research. The author has found it advantageous to work within this framework; it is hoped the reader will as well.

Dr. Wayne Van Huss suggested and sanctioned this alternation from the conventional. This author encourages continuation of this format when appropriate.

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# CHAPTER I

## INTRODUCTION

Even though strength development methods have been practiced since earliest time, there is still disagreement among researchers as to the best method for strength development.

One of the systematic approaches to strength development was progressive resistance exercise or isotonics which loads a dynamically contracting muscle with weights or equivalent so that speed varies and resistance remains constant (as limited by gravity) over a full range of motion. It has been shown that isotonic training results in strength gains. Research has been undertaken comparing various combinations of resistance and repetitions to find the best approach for maximal strength improvement (3,22,23,27).

A second systematic approach was isometrics which loads a muscle so that speed is zero and resistance is proportional to muscular capacity in static positions. It has also been shown that isometric training results in strength gains (4,14,21).

There have been studies that have shown both methods to significantly increase strength but with no significant difference between methods (24,25,28,29,30). However, there have also been contradicting studies comparing isometrics and isotonics. For example, Berger and Rapp showed that an isotonic program was more effective than an isometric program in improving the vertical jump (6). In contrasting effects of isotonic and isometric training on the vertical jump, Hannett found a

mean increase of 3.3 inches for his isometric group, and 2.6 inches for his isotonic group, and 1.4 inches for his control group. Improvements within each group were significant at the .05 level (26).

To complicate the already confusing field of strength development a new concept in strength development has been developed to challenge isotonics and isometrics called isokinetics or accommodating resistance exercise (ARE). In this program a muscle is loaded dynamically so that movement is at a fixed rate of speed and resistance is directly proportional to the magnitude of the input at every given point in the range of movement.

There have been recorded limitations which are inherent in both isotonic and isometric training programs (16). Clarke, for example, has described the variations in muscular force throughout a full range of motion resulting in sub-maximal loadings of the muscle (1).

The research completed thus far indicates that isokinetic programs will increase strength significantly. Thistle reported that after an eight week period of exercise involving sixty subjects, the experimental group using isokinetics showed an improvement of 35.4% in total work ability while the group using isotonic methods improved only 27.5% and the group using isometric contractions improved only 9.2%. The results in peak force ability were more remarkable with the isokinetic group improving 47.2%, the isotonic group 28.6%, and the isometric group 12.1% (20).

Berg, utilizing a ten-week isokinetic program, has recently reported an overall gain of 26% in strength (7). Hislop and Perrine have taken the position that isokinetic exercise permits greater demands to be placed on muscular performance than have heretofore been possible (11).

Isokinetic exercise has received enthusiastic responses from athletes, coaches, trainers, physical educators, and physical therapists (8,9,10,12,13,15,17,18,19). It is clear, however, that careful and complete evaluation of isokinetic programs is needed.

## Statement of the Problem

To examine the effects of isometric, isotonic, and isokinetic exercise under controlled conditions on the push-up achievement of high school boys. As a secondary problem, since the isokinetic exerciser utilizes a constant rate, the effects of varying rates upon push-up performance will be investigated.

## Limitations

This study was limited by the following factors.

1. The subjects knew they were part of a research study.
2. There was no control over diet, sleep, and other daily living habits.
3. Nothing was known about past training programs of the subjects.
4. The motivation of the subjects during testing and training may have been lacking; however, encouragement was given daily to each group.
5. The number of available subjects was small.
6. The study was limited to five weeks of training.

## CHAPTER II

## METHODS OF RESEARCH

### Design

The design of the study was a 4x3, 2-way Analysis of Variance.

| | | FACTOR A = TREATMENT | | | |
|---|---|---|---|---|---|
| | | Control | Isometric | Isotonic | Isokinetic |
| FACTOR B = PUSH-UP RATE | Normal | | | | |
| | Medium | | | | |
| | Slow | | | | |

### Subjects

Twenty-eight subjects were randomly selected from a sixth hour physical education class at Sexton High School (Lansing, Michigan). There were no prerequisites for this class. The subjects were randomly assigned to four treatment groups. Due to absenteeism and personal injury, only twenty-three subjects were used in the final analysis.

### Treatment Groups

The four treatment groups were defined as follows: Group A-Control, Group B-Isometric, Group C-Isotonic, Group D-Isokinetic. The study was conducted over a period of five weeks.

## Training Procedure

The subjects of Group A (N=7), the control group, participated in the regular physical education class. During the study the physical education class had received instruction in golf and swimming. The writer asked these subjects not to become involved in any training programs that might involve the upper extremities.

The subjects of Group B (N=6), the isometric group, performed the bench press isometrically on a power rack at five different positions in the range of movement. These positions were approximately chest level, 90° of arm flexion, 115° of arm flexion, 140° of arm flexion, and 165° of arm flexion. Each subject was directed to sustain a 2/3 to maximum contraction for six seconds at each position in the range (4). The subjects trained three days a week. After their training session each subject returned to the regular physical education class.

The subjects of Group C (N=5), the isotonic group, performed three sets of eight repetitions in the bench press. The repetitions were performed at the same rate as the slow push-up rate. This rate was controlled by a metronome. DeLorme's progressive resistance program was followed in the training program. The first set consisted of 8 repetitions against one-half the subjects 8 repetition maximum (RM), the second set involved 8 repetitions with three-quarters of the 8 RM, and the final set of 8 repetitions was performed with the 8 RM (3). Whenever the subject progressed so that he could successfully complete all three sets of 8 repetitions, an additional 10 pounds of resistance was added and this new weight was then used as the 8 RM for subsequent training. The subjects trained three days a week. After their training session each subject returned to the regular physical education class.

The subjects of Group D (N=5), the isokinetic group, performed two sets of 8 repetitions at maximum resistance on an isokinetic exerciser, the Super Mini-Gym.[1] Two sets of 8 repetitions were performed in an attempt to equate the work in foot/lbs. in groups C and D. The subjects trained three days a week. After their training session each subject returned to the regular physical education class.

## Testing Procedure

Each subject was tested for the number of complete push-ups which could be achieved at three different push-up rates--normal, medium, and slow--determined from a pilot study. A complete push-up was defined as one where the subject performed a push-up maintaining the given rate with his back straight, head level, hands approximately shoulder width, and chest touching a block eight centimeters in height on the floor. Each subject was pretested and post-tested for the number of complete push-ups which could be achieved at the three push-up rates. The rate of each push-up was controlled by a metronome. The test order was randomly assigned to each subject with a five minute interval for recovery.

## Pilot

Prior to beginning the actual collection of data, a pilot study was undertaken to determine:

1. The variability of the data from which the sample size could be determined.

2. The reliability of testing procedures.

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[1]Super Mini-Gym, Indicator Model No. 250, Mgr. Mini-Gym, Inc., Box 266, Independence, Missouri 64051.

3. The push-up rates.

4. The potential administrative problems connected with the testing and training of the subjects.

The results of the pilot study were as follows:

1. The standard deviation of the available sample was 6.42. Based on this information and an $\alpha$=.05, $\beta$=.10, a necessary and sufficient n was determined to be 6 per treatment group (2).

2. The reliability of the testing procedures was r=0.925 for the normal rate and r=0.738 for the slow rate.

3. The normal push-up rate was determined to be 58.06 cm per second, the slow push-up rate was 24.58 cm per second, and the medium push-up rate was 41.32 cm per second. The slow rate was the rate of the isokinetic exerciser. The medium rate was midway between the normal and slow rates. From this information the metronome settings were normal-90, medium-64, and slow-38 beats per minute. In the testing procedure two beats constituted one complete push-up.

4. The height of the block used in the testing was changed from five centimeters in the pilot study to eight centimeters in the actual study.

## Statistical Treatment

A preliminary analysis of the correlation between cells was performed to determine if the assumptions could be met for Analysis of Variance. Since the assumptions were met the final analysis was a 4x3, 2-way ANOVA of gain scores with unequal n.

## CHAPTER III

## RESULTS

There was a question about the appropriate analysis for the data, Analysis of Variance or Analysis of Covariance. In Table 1 are the results of a preliminary investigation into the standard deviations, skewness, kurtosis, and correlations of the original data. As a result, it was decided that the appropriate analysis was an ANOVA of gain scores with unequal n.

Table 1. Summary of Bastat and correlations within cells

| | | | Treatments | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | Control | | Isometric | | Isotonic | | Isokinetic | |
| | | | Pre-test | Post-test | Pre-test | Post-test | Pre-test | Post-test | Pre-test | Post-test |
| Push-up Rate | Normal | Mean | 18.7 | 18.7 | 17.8 | 18.3 | 14.0 | 18.0 | 17.6 | 21.2 |
| | | Standard deviation | 7.3 | 6.9 | 5.0 | 5.7 | 6.1 | 6.7 | 8.2 | 6.9 |
| | | Skewness | -0.001 | 0.113 | 0.747 | 0.053 | -0.256 | 0.576 | 0.360 | -0.305 |
| | | Kurtosis | 1.708 | 1.577 | 2.827 | 2.444 | 2.372 | 2.013 | 2.503 | 2.319 |
| | | Correlation | .7211 | | .6595 | | .9241 | | .9592 | |
| | Medium | Mean | 17.3 | 16.7 | 18.7 | 19.3 | 15.8 | 18.0 | 15.6 | 18.6 |
| | | Standard deviation | 5.5 | 5.5 | 6.4 | 6.0 | 7.7 | 4.1 | 4.9 | 5.3 |
| | | Skewness | 0.390 | 0.801 | 0.094 | -0.879 | 0.251 | 0.000 | -0.068 | -0.330 |
| | | Kurtosis | 1.812 | 1.839 | 1.751 | 2.489 | 1.641 | 1.527 | 1.934 | 1.989 |
| | | Correlation | .8410 | | .5800 | | .7281 | | .8790 | |

Table 1 (cont'd.)

| | | | Treatments | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | Control | | Isometric | | Isotonic | | Isokinetic | |
| | | | Pre-test | Post-test | Pre-test | Post-test | Pre-test | Post-test | Pre-test | Post-test |
| Push-up Rate | Slow | Mean | 14.3 | 14.7 | 16.8 | 15.7 | 14.8 | 17.8 | 12.8 | 15.2 |
| | | Standard deviation | 4.8 | 6.3 | 5.0 | 6.2 | 6.4 | 7.8 | 2.7 | 3.5 |
| | | Skewness | 0.428 | 0.534 | -0.863 | 0.884 | -0.201 | 0.566 | 0.670 | 1.074 |
| | | Kurtosis | 3.105 | 2.010 | 2.824 | 3.146 | 1.745 | 1.637 | 2.310 | 2.524 |
| | | Correlation | .8425 | | .6564 | | .8370 | | .9123 | |

The findings of the study indicated an overall treatment effect significant at the .03 level, but there was no significance in the overall push-up rate effect or in any of the interactions between treatment and push-up rates, Table 3.

In post hoc examination of the treatment effects, neither the Scheffé nor the less rigorous Duncan or Student Newman Keul multiple comparison tests could detect a significance at the .05 level between the treatments. Table 4 summarizes the results of the mean gain scores for the treatments, push-up rates, and interactions.

Table 2 summarizes the pretest and post-test means for each treatment and push-up rate. In Figures 1 and 2 the mean differences between the pretest and post-test means are presented.

From the results it can be concluded that significant differences exist between treatments. Neither a rate effect nor any significant interactions were observed. Although on the basis of the mean values, an attractive explanation appeared probable in the differences between the Control-Isometric Groups and the Isotonic-Isokinetic Groups on the basis of the post hoc tests such an explanation was not legitimate. It

Table 2. Pretest and post-test mean values and mean changes in the treatment groups

| Groups | Pretest Means | Post-test Means | Mean Changes |
|---|---|---|---|
| Control | | | |
| Normal | 18.7 | 18.7 | 0.0 |
| Medium | 17.3 | 16.7 | -0.6 |
| Slow | 14.3 | 14.7 | 0.4 |
| Isometric | | | |
| Normal | 17.8 | 18.3 | 0.5 |
| Medium | 18.66 | 19.33 | 0.7 |
| Slow | 16.833 | 15.66 | -1.2 |
| Isotonic | | | |
| Normal | 14.0 | 18.0 | 4.0 |
| Medium | 15.8 | 18.0 | 2.2 |
| Slow | 14.8 | 17.8 | 3.0 |
| Isokinetic | | | |
| Normal | 17.6 | 21.2 | 3.6 |
| Medium | 15.6 | 18.6 | 3.0 |
| Slow | 12.8 | 15.2 | 2.4 |

Table 3. Analysis of variance for treatments, push-up rates, and interactions

| Source | Sum Squares | df | Mean Square | F | P |
|---|---|---|---|---|---|
| Treatment effect | 158.72 | 3 | 52.91 | 3.16 | .03 |
| Push-up rate effect | 9.44 | 2 | 4.72 | 0.28 | .76 |
| Treatment X push-up rate | 19.50 | 6 | 3.25 | 0.19 | .98 |
| Error | 954.30 | 57 | 16.74 | | |
| Total | 1140.61 | 68 | | | |

Figure 1

Mean Difference by Treatment Groups

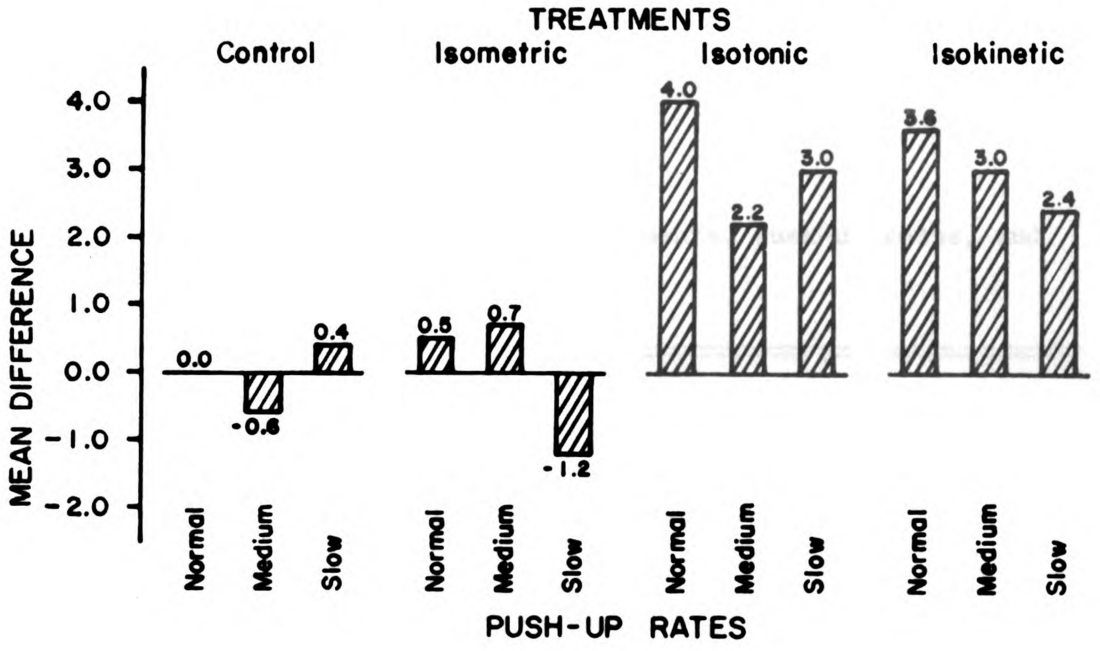
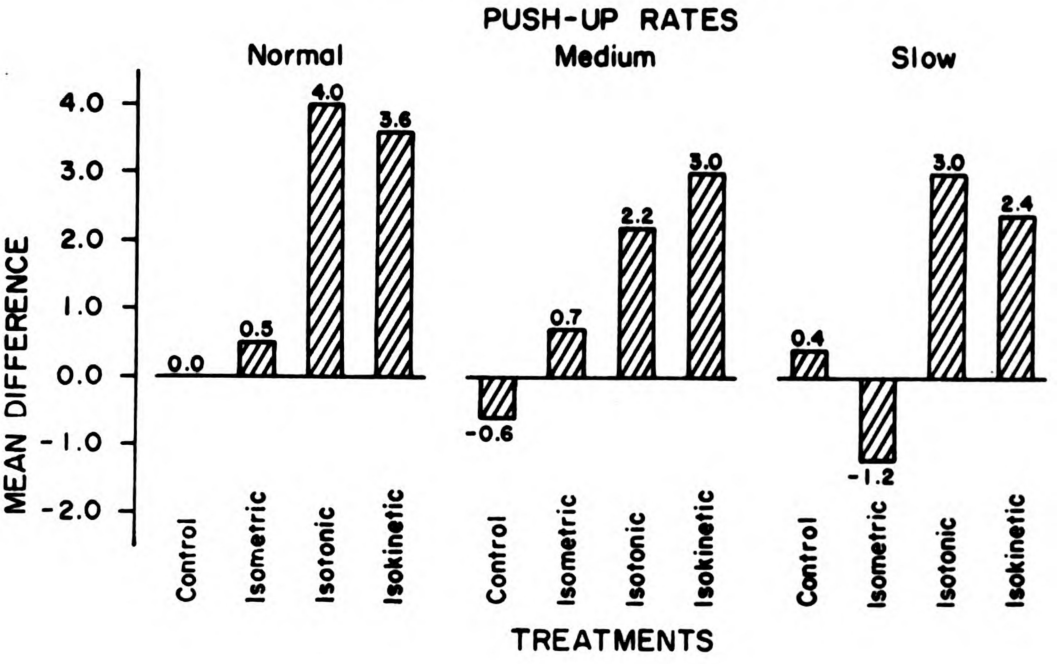



Figure 2

Mean Difference by Push-Up Rates



was also attractive to hypothesize a summing effect in the data from the different rates but again there is no statistical significance to support this position. Thus, the conclusion of the study necessarily must be limited to the significant differences between the four groups with no further definition.

Table 4. Table of mean gain scores for treatments, push-up rates, and interactions

| | | FACTOR A = TREATMENT | | | | Overall mean values by push-up rate |
|---|---|---|---|---|---|---|
| | | Control | Isometric | Isotonic | Isokinetic | |
| FACTOR B = PUSH-UP RATE | Normal | 0.0000 | 0.5000 | 4.0000 | 3.6000 | 1.8246 |
| | Medium | -0.5714 | 0.6667 | 2.2000 | 3.0000 | 1.1234 |
| | Slow | 0.4286 | -1.1667 | 3.0000 | 2.4000 | 0.9651 |
| Overall mean values by treatments | | -0.0476 | 0.0000 | 3.0667 | 3.0000 | 1.3044 |

# CHAPTER IV

# SUMMARY, CONCLUSION, AND RECOMMENDATIONS

## Summary

The purpose of the study was to examine the effects of isometric, isotonic, and isokinetic exercise under controlled conditions on the push-up achievement of high school boys. Since the isokinetic exerciser utilizes a constant rate, the effects of varying rates upon push-up performance was also examined.

Twenty-eight subjects were randomly selected from those enrolled in a sixth hour physical education class at Sexton High School (Lansing, Michigan). The subjects were randomly assigned to four treatment groups--control, isometric, isotonic, and isokinetic. Each subject was pretested for the number of complete push-up which could be achieved. Following a five week training program, each subject was post-tested for the number of complete push-ups which could be achieved. The design of the study was a 4x3, 2-way Analysis of Variance of gain scores with unequal n.

## Conclusion

Within the limitations of the study, there was a significant treatment effect at the .03 level, but neither the push-up rate effect nor the interactions were significant. However, in post hoc examination of the treatment effects, neither the Scheffé nor the less rigorous Duncan or Student Newman Keul multiple comparison tests could detect a

significance at the .05 level between treatments. Thus, the conclusion of the study necessarily must be limited to the significant differences between the four treatment groups with no further definition.

## Recommendations

Upon conclusion of the study the following considerations are recommended:

1. Increase the length of the study to ten weeks.
2. Increase the number of subjects to be used in the study.
3. Attempt to equate the training programs between experimental groups.
4. Attempt to control the motivation of the subjects while training and testing. This control is particularly important in the isometric and isokinetic groups.

# BIBLIOGRAPHY

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## Books


1. Clarke, H. H. *Muscular Strength and Endurance.* Englewood Cliffs: Prentice-Hall, Inc., 1966.

2. Cohen, J. *Statistical Power Analysis for the Behavioral Sciences.* New York: Academic Press, 1969.

3. DeLorme, T. L. and A. L. Watkins. *Progressive Resistance Exercise.* New York: Appleton-Century-Crofts, Inc., 1951.

4. Hettinger, T. *Physiology of Strength.* Springfield, Illinois: Charles C. Thomas, 1961.

5. Leighton, J. R. *Progressive Weight Training.* New York: Roland Press Co., 1961.


## Periodicals


6. Berger, R. A. and D. Rapp. "Effects of Dynamic and Static Training on Vertical Jumping Ability," *Research Quarterly*, 34:419-429, December, 1963.

7. "Changing Concepts in a Changing World of Sports," *Amateur Athlete*, September, 1970, pp. 37-38.

8. Chu, D. A. and G. Smith. "Isokinetic Exercise: Controlled Speed and Accommodating Resistance," *The Journal of the National Athletic Trainers Association*, 6:23-24, Spring, 1971.

9. Councilman, J. "Isokinetic Exercise: A New Concept in Strength Building," *Swimming World*, 10:60-61, November, 1969.

10. Hinson, M. and J. Rosentswieg. "Comparing the Three Best Ways of Developing Strength," *Scholastic Coach*, 41:34, March, 1972.

11. Hislop, H. and J. Perrine. "The Isokinetic Concept of Exercise," *Physical Therapy*, 47:114-117, February, 1967.

12. Lay, P. A. "Isokinetic Contractions: A New Concept of Accommodating Resistive Exercise," *The Athletics Coach*, 4:33, June, 1970.

13. Lossau, P. "New Adapted PE Program," *The Trapeze*, November 19, 1971, p. 6.

14. Muller, E. A. "The Regulation of Muscular Strength," *Journal of the Association for Physical and Mental Rehabilitation*, 11:41-47, March-April, 1957.

15. Moffroid, M. and others. "A Study of Isokinetic Exercise," *Physical Therapy*, 49:735-747, July, 1969.

16. Perrine, J. "Isokinetic Exercise and Mechanical Energy Potentials of Muscle," *Journal of Health, Physical Education, and Recreation*, 39:40-44, May, 1968.

17. Settino, H. L. and J. Disanza. "Developing Hitting and Throwing Strength Through Isokinetics," *Coach and Athlete*, 33:14, February, 1971.

18. Spackman, R. "A New Approach to Strength Building," *Athletic Journal*, 51:70-71, January, 1971.

19. "Stubborn Machine Helps Retain Muscles," *Medical World News*, September 23, 1966, p. 70.

20. Thistle, H. G. and others. "Isokinetic Contraction: A New Concept of Resistive Exercise," *Archives of Physical Medicine and Rehabilitation*, 48:279-282, June, 1967.

21. Vander Hoff, E. R. and others. "Effects of Muscle Strength and Endurance Development on Blood Flow," *Journal of Applied Physiology*, 16:873-877, September, 1961.

Unpublished Materials

22. Barney, V. S. "A Comparison of DeLorme's Techniques of Progressive Resistance Exercise with a Modified Technique." Unpublished Doctor's dissertation, Brigham Young University, 1956.

23. Berger, R. A. "The Effects of Varied Weight Training Programs on Strength and Endurance." Unpublished Doctor's dissertation, University of Illinois, 1960.

24. Bergeron, P. "The Effects of Static Strength Training at Various Positions and Dynamic Strength Training Through a Full Range of Motion on Strength, Speed of Movement, and Power." Unpublished Doctor's dissertation, Louisiana State University, 1966.

25. Grouwinkle, G. "A Comparison of the Effect of Isotonic Exercise and Isometric Exercise on Speed of Arm Movement and on Arm Strength." Unpublished Master's thesis, State University of Iowa, 1964.

26. Hannett, J. L. "The Effects of an Isometric Training Program and a Weight Training Program on the Vertical Jump, Dynamic Strength, Static Strength, and Thigh Girth in Male College Students." Unpublished Master's thesis, Michigan State University, 1964.

27. Hoffman, J. A. "A Comparison of the Effects of Two Programs of Weight Training on Explosive Force." Unpublished Master's thesis, South Dakota State College, 1959.

28. Kruse, R. D. "The Effects of Varying Frequencies of Training Sessions upon Strength of Elbow Flexor Muscle Groups." Unpublished Doctor's dissertation, Springfield College, 1956.

29. McCall, G. "The Ipsilateral and Contralateral Effects of Isotonic versus Isometric Unilateral Training." Unpublished Master's thesis, Long Beach State College, 1963.

30. Ward, P. E. "The Effects of Isometric and Isotonic Exercises on Strength, Endurance, and Anthropometric Measurements." Unpublished Master's thesis, University of Washington, 1963.

# APPENDIXES

# APPENDIX A

# PILOT DATA

Table A-1. Pilot data: reliability of testing procedure

| Subject | Push-up Pretest Order Tests Given | Testing Rates Normal | Slow | Push-up Post-test Order Tests Given | Testing Rates Normal | Slow |
|---|---|---|---|---|---|---|
| Edy | slow - nor | 11 | 13 | slow - nor | 10 | 9 |
| Farmer | nor - slow | 30 | 18 | slow - nor | 27 | 23 |
| Garner | slow - nor | 17 | 13 | nor - slow | 17 | 11 |
| Goodenow | slow - nor | 15 | 14 | nor - slow | 13 | 10 |
| Jackson | nor - slow | 31 | 17 | nor - slow | 35 | 17 |
| Jordon | slow - nor | 15 | 11 | slow - nor | 15 | 12 |
| Monahan | slow - nor | 27 | 21 | slow - nor | 22 | 18 |
| Phillips | nor - slow | 25 | 14 | slow - nor | 20 | 17 |
| Ruhno | nor - slow | 25 | 10 | slow - nor | 20 | 11 |
| Satterlee | slow - nor | 17 | 12 | nor - slow | 14 | 13 |

Testing Rates: normal - 120 beats per minute

slow - 38 beats per minute

Results

1. $r_{normal} = .925$
2. $r_{slow} = .738$

Table A-2. Pilot data: standard deviation of push-ups and mean rate of a normal push-up

| Subject | Number of Push-ups | Arm Length in Centimeters | Time for 10 Repetions in Seconds |
|---|---|---|---|
| Edy | 11 | 44 | 16.5 |
| Farmer | 30 | 46 | 13.6 |
| Garner | 17 | 49 | 13.2 |
| Goodenow | 15 | 46 | 18.0 |
| Jackson | 31 | 45 | 14.9 |
| Jordon | 15 | 48 | 12.0 |
| Monahan | 27 | 44 | 12.8 |
| Phillips | 25 | 50 | 14.3 |
| Ruhno | 25 | 46 | 12.2 |
| Satterlee | 17 | 50 | 16.5 |

Results

1. Standard deviation = 6.42
2. Mean arm length = 46.8
3. Mean time for 1 repetition = 1.44 sec.
4. Mean distance moved on 1 repetition = 93.6-10=83.6 cm
5. Rate of normal push-up = 58.06 cm per sec

Table A-3. Pilot data: rate of isokinetic exerciser (Super Mini-Gym)

| Actual Resistance in Pounds | Resistance Reading on Super Mini-Gym | Time in Seconds to Move 100 cm for each trial |
|---|---|---|
| 50 | 125 | 4.6, 4.5, 4.5, 4.5, 4.4 |
| 100 | 225 | 4.2, 4.1, 4.1, 4.0, 3.9 |
| 150 | 325 | 4.1, 4.0, 4.0, 3.9, 3.8 |
| 200 | 425 | 4.0, 4.0, 3.9, 3.9, 3.8 |
| 250 | above the Mini-Gym scale | 4.0, 3.9, 3.8 |

Results

1. Mean time to move 100 cm = 4.068 sec
2. Rate of Super Mini-Gym = 24.58 cm per sec

Table A-4. Pilot data: push-up rates and metronome settings

1. Push-up Rates

   Normal - 58.06 cm per sec

   Medium - 41.32 cm per sec

   Slow - 24.58 cm per sec

2. Distance moved on each repetition = 77.6 cm

   Mean distance moved - block height (8 cm)

   93.6 - 16
   77.6 cm

3. Time for each push-up rate repetition

   Normal - 1.34 sec

   Medium - 1.88 sec

   Slow - 3.16 sec

4. Metronome settings for push-up rates

   Normal - 90 beats per minute

   Medium - 64 beats per minute

   Slow - 38 beats per minute

# APPENDIX B

# TESTING DATA

Table B-1. Testing data: pretest and post-test data

| Control Group | Push-up Pretest | | | | Push-up Post-test | | | |
|---|---|---|---|---|---|---|---|---|
| | Order | Testing Rates | | | Order | Testing Rates | | |
| Subjects | Tests Given | Nor | Med | Slow | Tests Given | Nor | Med | Slow |
| Fay | NMS | 24 | 20 | 16 | SMN | 22 | 24 | 11 |
| Ellis | MNS | 17 | 26 | 15 | NSM | 26 | 25 | 21 |
| Guyselman | MNS | 9 | 15 | 12 | SMN | 10 | 14 | 12 |
| P. Johnson | SNM | 29 | 22 | 23 | NSM | 28 | 16 | 25 |
| Loggins | NMS | 11 | 12 | 7 | MSN | 12 | 13 | 7 |
| Philo | NSM | 24 | 11 | 14 | SMN | 15 | 12 | 16 |
| Stalker | MSN | 17 | 15 | 13 | SNM | 18 | 13 | 11 |
| **Isometric Group** | **Push-up Pretest** | | | | **Push-up Post-test** | | | |
| | Order | Testing Rates | | | Order | Testing Rates | | |
| Subjects | Tests Given | Nor | Med | Slow | Tests Given | Nor | Med | Slow |
| Crouch | NMS | 9 | 10 | 8 | MNS | 10 | 9 | 8 |
| Davis* | NSM | 22 | 11 | 9 | MNS | -- | -- | -- |
| Eberly | SMN | 20 | 16 | 22 | MSN | 15 | 25 | 13 |
| Eschbach | SNM | 17 | 15 | 17 | NMS | 18 | 21 | 15 |
| Griffin | MNS | 24 | 27 | 17 | NMS | 20 | 21 | 16 |
| Kuhn | MSN | 20 | 25 | 21 | NSM | 27 | 24 | 27 |
| Tremblay | SMN | 17 | 19 | 16 | NMS | 20 | 16 | 15 |

Push-up Test Rates

N - normal
M - medium
S - slow

*Subject not used in final analysis as he did not finish study.

Table B-1 (cont'd.)

| Isotonic Group | Push-up Pretest | | | | Push-up Post-test | | | |
|---|---|---|---|---|---|---|---|---|
| | Order | Testing Rates | | | Order | Testing Rates | | |
| Subjects | Tests Given | Nor | Med | Slow | Tests Given | Nor | Med | Slow |
| Brown* | MSN | 12 | 12 | 9 | NSM | 12 | 11 | 12 |
| Glisson | MSN | 16 | 26 | 20 | SNM | 21 | 21 | 29 |
| B. Johnson* | SMN | 23 | 25 | 24 | MNS | 28 | 18 | 17 |
| Kirvan | SNM | 13 | 11 | 12 | NMS | 16 | 18 | 11 |
| Lintemuth | MSN | 5 | 7 | 6 | MNS | 11 | 15 | 12 |
| Reemsnyder | SNM | 14 | 14 | 14 | SMN | 14 | 13 | 14 |
| Sinko | MSN | 22 | 21 | 22 | MSN | 28 | 23 | 23 |
| Isokinetic Group | Push-up Pretest | | | | Push-up Post-test | | | |
| | Order | Testing Rates | | | Order | Testing Rates | | |
| Subjects | Tests Given | Nor | Med | Slow | Tests Given | Nor | Med | Slow |
| Foster* | NMS | 15 | 19 | 13 | MSN | 16 | 20 | 13 |
| Gaffee | NMS | 17 | 22 | 17 | MNS | 24 | 25 | 21 |
| Magee | MNS | 7 | 9 | 10 | SNM | 11 | 11 | 13 |
| Redburn | NMS | 30 | 18 | 13 | SMN | 30 | 21 | 13 |
| Ward | NSM | 16 | 13 | 11 | NSM | 20 | 20 | 13 |
| Woods | NSM | 18 | 16 | 13 | SNM | 21 | 16 | 16 |
| Zillizitt* | SNM | 8 | 9 | 8 | MSN | -- | -- | -- |

Push-up Test Rates

N - normal
M - medium
S - slow

*Subject not used in final analysis as he did not finish study.

# APPENDIX C

# TRAINING DATA

Table C-1. Training data: isometric group

| Subjects | Date | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | May | | | | | | | | | | | June | | | |
| | 8 | 10 | 12 | 15 | 17 | 19 | 22 | 24 | 26 | 29 | 31 | 2 | 5 | 7 | 8 |
| Crouch | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ |
| Davis | ✓ | ✓ | ✓ | | | | ✓ | | | | | | | | |
| Eberly | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ |
| Eschbach | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ |
| Griffin | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ |
| Kuhn | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ |
| Tremblay | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ |

✓ - performed isometric exercises for that date.

Table C-2. Training data: isotonic group

| Subjects | Date: May 8 | 10 | 12 | 15 | 17 | 19 | 22 | 24 | 26 | 29 | 31 | June 2 | 5 | 7 | 8 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | * ** | | | | | | | | | | | | | | |
| Brown | 50-8 | 40-8 | 8 | 8 | | | | 8 | | | | | 8 | | 8 |
| | 75-8 | 60-8 | 8 | 8 | | | | 8 | | | | | 8 | | 8 |
| | 100-0 | 80-1 | 3 | 5 | | | | 3 | | | | | 4 | | 4 |
| Glisson | 50-8 | 55-8 | 60-8 | 8 | 65-8 | 8 | 8 | 8 | 70-8 | 8 | 8 | 8 | 8 | 8 | 8 |
| | 75-8 | 82.5-8 | 90-8 | 8 | 97.5-8 | 8 | 8 | 8 | 105-8 | 8 | 8 | 8 | 8 | 8 | 8 |
| | 100-8 | 110-8 | 120-7 | 8 | 130-6 | 7 | 6 | 8 | 140-5 | 3 | 2 | 3 | 6 | 7 | 7 |
| R. Johnson | 50-8 | 40-8 | 45-8 | 50-8 | | | | | | | | | 55-8 | 60-8 | 8 |
| | 75-8 | 60-8 | 67.5-8 | 75-8 | | | | | | | | | 82.5-8 | 90-8 | 8 |
| | 100-1 | 80-8 | 90-8 | 100-8 | | | | | | | | | 110-8 | 120-3 | 5 |
| Kirvan | 50-8 | 35-8 | 40-8 | 8 | 8 | 8 | 8 | 8 | 8 | 45-8 | 8 | 8 | 8 | 8 | 50-8 |
| | 75-4 | 52.5-8 | 60-8 | 8 | 8 | 8 | 8 | 8 | 8 | 67.5-8 | 8 | 8 | 8 | 8 | 75-8 |
| | 100-0 | 70-8 | 80-5 | 6 | 6 | 5 | 6 | 5 | 8 | 90-5 | 5 | 7 | 6 | 8 | 100-2 |
| Lintemuth | 50-8 | 40-8 | 45-8 | 50-8 | 55-8 | 8 | 8 | 8 | 8 | 8 | 8 | 8 | 8 | 60-8 | 8 |
| | 75-8 | 60-8 | 67.5-8 | 75-8 | 82.5-8 | 8 | 8 | 8 | 8 | 8 | 8 | 8 | 8 | 90-8 | 8 |
| | 100-2 | 80-8 | 90-8 | 100-8 | 110-1 | 3 | 5 | 6 | 1 | 1 | 4 | 5 | 8 | 120-3 | 7 |
| Reemsnyder | 50-8 | 40-8 | 45-8 | 50-8 | 8 | 55-8 | 8 | 8 | 8 | 8 | 8 | 8 | 8 | 60-8 | 8 |
| | 75-8 | 60-8 | 67.5-8 | 75-8 | 8 | 82.5-8 | 8 | 8 | 8 | 8 | 8 | 8 | 8 | 90-8 | 8 |
| | 100-1 | 80-8 | 90-8 | 100-7 | 8 | 110-4 | 2 | 3 | 3 | 4 | 5 | 6 | 8 | 120-5 | 7 |
| Sinko | 50-8 | 8 | 8 | 55-8 | 8 | 8 | 8 | 60-8 | 8 | 65-8 | 8 | 8 | 8 | 8 | 8 |
| | 75-8 | 8 | 8 | 82.5-8 | 8 | 8 | 8 | 90-8 | 8 | 97.5-8 | 8 | 8 | 8 | 8 | 8 |
| | 100-7 | 7 | 8 | 110-7 | 6 | 7 | 8 | 120-6 | 8 | 130-6 | 2 | 4 | 5 | 5 | 4 |

Sets: 1st-1/2 8 RM 2nd-3/4 8 RM 3rd-8 RM increase 10 pounds

*Resistance in pounds; **Repetitions per set

Table C-3. Training data: isokinetic group

| Subjects | May 8 | 10 | 12 | 15 | 17 | 19 | Date 22 | 24 | 26 | 29 | June 31 | 2 | 5 | 7 | 8 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Foster | | 135* | 175 | | | | 160 | 155 | 160 | 160 | 175 | | | | |
| | | 175 | 180 | | | | 175 | 180 | 180 | 180 | 175 | | | | |
| Gaffee | 155 | 185 | 200 | 200 | 195 | 200 | 210 | 200 | 200 | 190 | 210 | 205 | 205 | 200 | 200 |
| | 175 | 190 | 205 | 205 | 200 | 195 | 205 | 210 | 200 | 205 | 225 | 210 | 215 | 215 | 200 |
| Magee | 135 | 130 | 140 | 155 | 165 | 175 | 160 | 160 | 150 | 190 | 145 | 160 | 215 | 200 | 185 |
| | 120 | 150 | 175 | 170 | 125 | 170 | 155 | 160 | 170 | 155 | 140 | 175 | 155 | 150 | 145 |
| Redburn | 250 | 275 | 245 | 255 | 250 | 250 | 300 | 260 | 220 | 260 | 255 | 245 | 240 | 240 | 250 |
| | 270 | 260 | 245 | 250 | 260 | 255 | 290 | 255 | 245 | 250 | 250 | 250 | 255 | 255 | 240 |
| Ward | 210 | 250 | 235 | 240 | 225 | 275 | 230 | 235 | 245 | 240 | 240 | 220 | 220 | 235 | 225 |
| | 235 | 250 | 240 | 240 | 300 | 240 | 220 | 225 | 240 | 220 | 215 | 225 | 235 | 240 | 235 |
| Woods | 130 | 150 | 150 | 175 | 160 | 170 | 170 | 165 | 160 | 160 | 200 | 185 | 175 | 185 | 160 |
| | 150 | 175 | 145 | 155 | 155 | 170 | 160 | 195 | 175 | 180 | 195 | 185 | 175 | 200 | 170 |
| Zillizitt | 175 | 180 | 180 | 205 | 205 | 200 | 205 | 180 | 165 | 170 | 180 | 180 | | | |
| | 170 | 175 | 200 | 185 | 200 | 215 | 180 | 190 | 180 | 175 | 175 | 170 | | | |

*Reading on Super Mini-Gym Exerciser.