San Fernando Valley State College

THE EFFECTS OF THREE TECHNIQUES OF ISOTONIC TRAINING ON THE DEVELOPMENT OF STRENGTH AND STRENGTH ENDURANCE

A thesis submitted in partial satisfaction of the requirements for the degree of Master of Arts in Physical Education

by

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June, 1968
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ABSTRACT

THE EFFECTS OF THREE TECHNIQUES OF ISOTONIC TRAINING ON THE DEVELOPMENT OF STRENGTH AND STRENGTH ENDURANCE

by

Dudley Myron Gibford

Master of Arts in Physical Education

June, 1968

This study was designed to investigate the effects of three isotonic training programs on the development of strength and strength endurance of tenth grade high school boys. The specific body area involved was the elbow extensors as used in the bench press exercise. The three training programs were:

(1) Training with three sets of six repetitions at maximum weight, (2) Training with one set of six repetitions at maximum weight, and (3) Training using a single repetition at maximum weight.

Strength was determined by a 1 R M isotonic bench press (one repetition at maximum overload). Strength endurance was determined by a test of maximum repetitions using 80 per cent of 1 R M on the isotonic bench press.

Forty subjects were randomly assigned to groups based on initial strength gain as determined by Muller's
formula. Ten subjects were dropped for failure to meet the requirements of the investigation.

The design of the twelve week study was as follows: Pre-experimental or familiarization phase—three weeks; Strength pre-tests—one week; Experiment—six weeks; Strength post-tests—one week; and Strength Endurance Tests—one week. Training sessions were conducted on Monday, Wednesday, and Friday throughout the study. During the pre-experimental phase all subjects trained with one set of ten repetitions at maximum weight. Each subject was given two pre-tests and assigned to one of the three experimental training programs. At the conclusion of the training program two post-strength tests and two strength endurance tests were conducted.

All three groups had a significant strength gain at the .05 level of confidence. The group that trained with three sets of six repetitions at maximum weight was significantly better than the other two groups at the .05 level of confidence. There were no significant differences between the other two groups. No significant differences were found in strength endurance between groups.
CHAPTER I

INTRODUCTION

Muscular strength is one of the primary factors in achieving success in sport activities. Individuals must have a sufficient level of strength to participate in sports, and in many skills the degree of success is determined by the strength of the individual (19:66). To develop this needed strength more and more high schools are including isotonic weight training in their physical education programs. One of the first problems which schools encounter with a new program of this nature is how to determine the best method of training.

The research work of Berger (2, 3, 4, 5, 6) provides considerable information on training techniques using the isotonic method. In his findings he reported that each technique had at least one or two training programs that were more effective than the others. The question yet unanswered, however, is whether the best of each technique is significantly different. This study proposes to test the relative effectiveness of these better techniques. In addition, three approaches planned for this investigation that are not commonly found in most strength studies are: (1) The use of high school
students; (2) The use of a preliminary training program for familiarization; and (3) The random assignment of subjects to training groups based on the subject's percentage of strength gain.

**Statement of the Purpose**

The purpose of this study was to investigate the effects of three isotonic training programs on the development of strength and strength endurance.

**Hypotheses**

The following null hypotheses were tested in this study: That no differences exist in training effects on strength using three methods of isotonic training as described in this investigation; that no differences exist in training effects on strength endurance using three methods of isotonic training as described in this investigation.

**Statement of the Problem**

The specific problem of this investigation was to determine if differential training effects occurred from the following three programs of training: (1) Training with three sets of six repetitions at maximum weight; (2) Training with one set of six repetitions at maximum weight; (3) Training using a single repetition at maximum weight.
Importance of the Study

This study was designed to compare three tested techniques of isotonic strength development using high school boys as subjects. An evaluation to determine the most effective isotonic technique in the development of strength and strength endurance is needed. Since most research studies of this nature have used college age men as subjects there is considerable need for determining the effect of training on adolescent populations. This study is a probe into the problem of determining the best method of isotonic training for high school boys.

Scope and Limitations

The subjects used in this study were forty boys who were members of the investigator's period two, tenth grade Boys' Physical Education class at Sylmar High School. The investigation was conducted over a twelve week period and was confined to the effects of isotonic bench press exercise on strength and strength endurance. Strength was determined by the 1 R M method and strength endurance by the maximum number of repetitions using eighty per cent of 1 R M.

The limitations of the study were: (1) A class period of forty-five minutes; (2) A class size of sixty-two students; (3) The use of adjustable barbells
and standard school benches; (4) Supervision by one instructor; (5) The experiment had to be conducted within the class period; (6) One planned day for training was postponed until the following day because of school activities. An in-training test was conducted during various periods of the school day because of a school activity; (7) The subjects were requested not to participate in weight training or similar exercise to the bench press during the course of the investigation, however, there was no way to insure that this restriction was not violated.

Definitions of Terms

For the purpose of this study the following terms were defined:

**Strength.**—The ability to exert maximum force as measured by a single repetition of maximum resistance in the isotonic bench press exercise (I R M).

**Strength Endurance.**—The ability to exert the maximum number of repetitions in the isotonic bench press exercise using eighty per cent of the I R M.

**Repetition.**—The movement of the barbell from a position on the chest to complete extension of the arms.

**Set.**—A prescribed number of repetitions executed consecutively and without rest.
Statistically Significant.—Statistical significance acceptable for the purpose of this study was set at the .05 level of confidence.

Organization of the Remaining Chapters

Chapter II Consists of a review of the literature which was deemed relevant to the present investigation. The research design and procedures utilized in the study are described in Chapter III. Statistical analysis and interpretation are outlined in Chapter IV, and Chapter V provides a discussion of the findings. The final chapter summarizes the experiment, its major findings, the conclusions which were drawn from the findings and the recommendations for future investigation.
CHAPTER II

REVIEW OF THE RELATED LITERATURE

The use of resistive exercises for the express purpose of building strength dates back many centuries. However, most of the scientific literature on the subject has been written in the past thirty years. During this period several isotonic techniques of strength development have been investigated. These investigations can be divided into two categories. The first category includes the studies involving the DeLorme technique or modifications of his system. The second category consists of the series of techniques studied by Berger.

For the purpose of this study the review of the literature will be divided into three parts: The DeLorme technique, Berger's investigations of various techniques, and the implications for the present study.

The DeLorme Technique

DeLorme (1) in his work with weakened quadriceps found that isotonic training improved strength. He used a program of 70-100 repetitions per session in sets of seven to ten and a maximum of
fifteen repetitions per set. All subjects trained five days per week. He used a 1 R M and a 10 R M to test strength gain each week.

In 1948 DeLorme (11) modified his technique to the following program: First set: ten repetitions of fifty per cent of 10 R M; Second set: ten repetitions of seventy-five per cent of 10 R M; Third set: 10 R M.

Several modifications of the DeLorme technique were introduced and compared. One such program termed the "Oxford Technique" was developed in England. It consisted basically of the DeLorme technique in reverse order. Zinovieff (21) proposed the "Oxford Technique" in 1951. He found by using the DeLorme method with weakened quadriceps that muscle fatigue affected the quality of performance and the subjects were not able to complete the full range of motion. The "Oxford Technique" consisted of ten sets of ten repetitions. The first set was 10 R M. Then the weight was reduced each succeeding set. Zinovieff used one pound increments for the quadriceps.

The modified DeLorme Technique and the Oxford Technique were later compared by McMorris and Elkins (17). In this study of twelve subjects both groups trained five days per week for twelve weeks, tested for 10 R M on the sixth day and rested on the seventh
day. The decreasing resistance group was better than the modified DeLorme group by 5.5 per cent. The significance was not reported. The authors believed that an experiment using larger numbers of subjects was needed before it could be concluded that these techniques produce significantly different results.

McGovern (16) compared the modified DeLorme program to a two set program of five repetitions at fifty per cent 10 R M. The subjects trained five times per week for four weeks. No significant difference between the groups was found.

In another variation of the DeLorme technique Kursen (15) compared two programs. One group used five repetitions with twenty-five per cent of 5 R M, then fifty per cent of 5 R M, then seventy-five per cent of 5 R M. The other group used 5 R M, maximum repetitions with 125 per cent of 5 R M, and maximum repetitions of 150 per cent of 5 R M. There was no significant difference between the groups.

The most recent study using the DeLorme Technique was by Barney and Bangerter (1) in 1961. They used three groups training three days per week for eight weeks and tested with a 1 R M and a 10 R M. One group used the modified DeLorme Technique, one used three sets of 10 R M, and a third group used a progressive program. The progressive program started
with 10 R M, then increased five to ten pounds per set executing maximum repetitions until only 1 R M could be done. All groups had a strength gain significant at the .01 level of confidence. There was no significant difference between groups using 1 R M as a test. When 10 R M was used as a test the modified DeLorme group was significantly better than the other two at the .01 level of confidence.

Berger's Investigations in Strength Development

Berger conducted a series of studies (2,3,4,5,6) on strength development programs in an attempt to determine the effects of repetitions, sets, submaximal efforts and rate of working. These studies will be reviewed in chronological sequence. In most of Berger's works the subjects trained on Monday, Wednesday, and Friday and used a 1 R M to determine strength. The first study (4) analyzed the effects of various repetitions and sets on the triceps as determined by the bench press exercise. There were nine groups. They used repetitions of two, six, and ten, and one, two, and three sets. At the end of six weeks three sets of six (3/6) were significantly better than 1/6, 1/2, 1/10, 2/10 at the .05 level of confidence. Three sets were significantly better than one or two sets at the .05 level of confidence. Six
repetitions were better than ten and significantly better than two at the nine and twelve week mark. All groups had significant increases in strength gain.

In another investigation using a similar design, Berger (5) compared the effects of one set of two, four, six, eight and ten repetitions. Four and eight repetitions were better than two or ten. Four, six, and eight repetitions were better than two. These differences were significant at the .05 level of confidence.

In a study similar in design to the previous studies, Berger (2) examined the effect of training with a submaximal load. The first group used 10 R M three times per week, the other used ninety per cent 10 R M twice a week and 10 R M once a week. Both groups had significant gains with no significant differences between the groups. The number of sets used in this investigation was not reported.

In a six week study (3), seven strength development programs for the knee flexors were examined using 1 R M as the strength test. One group used one set of maximum repetitions with two-thirds of their 1 R M twice a week and 1 R M test once a week. The second group used one set of maximum repetition with eighty per cent of 1 R M twice a week and a 1 R M test once a week. The third group used one set of maximum
repetition with ninety per cent 1 R M twice a week and 1 R M test once per week. The seventh group used 1 R M three times per week. The fifth used one set of maximum repetition with two-thirds of 1 R M three times per week with a 1 R M at three and six weeks. The 1 R M was given the sixth group once a week. The control group did 1 R M before and after six weeks. Only the groups using 1 R M test once per week had significant gains. Berger concluded that the increase in strength was due to the 1 R M test.

Berger and Harris (6) studied the effect of different rates of working. They used three groups. The first group used one set of eighteen to twenty repetitions in twenty-five seconds, the second used one set of eight to ten repetitions in twenty-five seconds, the third used one set of four repetitions in twenty-five seconds. All groups had significant strength gains as determined from 1 R M. All groups had significant increases in strength endurance using fifty per cent initial 1 R M at the rate of one repetition every two seconds. There were no significant differences between groups either with strength gain or strength endurance.

Implications for the Present Study

Berger found that three sets of six and one set
of six were the better techniques for training college age men in the bench press exercise. Another study found that 1 R M, three times per week, increased knee flexor strength significantly. The differences between these techniques, however, were not determined. This study determined the effects of these techniques on high school boys using the bench press exercise.

Berger found a strength reliability of .97 and .98 (2,4,5,6). This study determined the reliability of a strength test with high school boys.
CHAPTER III

EXPERIMENTAL PROCEDURES

The purpose of this investigation was to find the effects of three weight training programs on the development of strength and strength endurance. Included in this chapter are discussions related to the subjects, the tests, instrumentation, the individual phases of the study, and the statistical design.

Subjects

Selection of Subjects

The subjects for this study were the investigator's period two tenth grade Physical Education class at Sylmar High School. The number in the class totaled sixty-two. None of these students participated in inter-scholastic athletics or intramural programs during the study.

All subjects who started the experiment were allowed to train even if their attendance eliminated them from the study.

Subject's Class Activities

During the pre-experimental period (weeks one
through three), the subjects exercised on Monday, Wednesday, and Friday in accordance with the design of the investigation and then completed the class period by playing basketball. On the experimental test days the subjects played ping-pong or basketball after the testing. On Tuesday and Thursday the subjects participated in a basic swimming program to fulfill their physical education requirement. During the experimental period and for the remainder of the study the subjects participated in touch football during the days that the experiment was not conducted and basketball was continued for the days of the experimental training. Push-ups or similar exercises were not conducted during the twelve week period of the study.

Experimental Groups

To qualify for an assignment to an experimental group a subject had to complete at least three of the four practice sessions before the preliminary test and at least two of the three practice sessions between the preliminary test and the pre-tests. The subject was also required to take the preliminary test and both pre-tests. Forty students qualified as subjects for the study.

To be considered in the final statistical
analysis of the study the subject had to train for at least thirteen of the seventeen practice sessions or seventy-six per cent and complete all the tests. Thirty subjects met the criteria for the strength evaluation and twenty-eight for the strength endurance evaluation.

Tests

Strength Test

The 1 R M strength test was used in this investigation. The test was conducted with the subject lying supine on the bench with his feet flat on the floor. He grasped a barbell with his hands twelve inches apart. The width of the grasp was determined by measuring several boys' shoulder width grasp. These boys were similar in stature to the largest subjects used in this study. The grip was standardized with a three inch wide strip of white tape at the appropriate place on each end of the bar.

The initial position of the barbell was on the chest. It was placed there by two spotters. The bar was pressed to full arm extension. At that point the bar was taken by the spotters. During the test the subject's feet maintained contact with the floor and his buttocks with the bench. The subject started with his previous maximum weight and if he was
successful in lifting it he added two and one-half pounds each time until he could not successfully press it. If the subject was unsuccessful in lifting the original amount the weight was reduced at two and one-half pound intervals until the subject could successfully press the barbell. The rest interval between attempts was approximately thirty seconds. Only one attempt was allowed at each weight.

**Strength Test Instructions**

The following instructions were given all subjects at each testing session:

Today will be an official test. The test will consist of one maximum repetition or as much as you can press at one time. The method of lifting will be the same as the method in training except you only need to lift the barbell one time. You will begin with the maximum weight you pressed on the last test. If you can lift this weight it will be increased two and one-half pounds. If you are unable to press the beginning weight, the weight will be reduced two and one-half pounds each time until you are able to lift the weight.

While you are waiting to be tested you may play ping-pong or sit and relax. After you have been tested you may choose either ping-pong or basketball.

Here are some points to remember: (1) Remain in the gymnasium until you are called to be tested; (2) Keep your buttocks flat on the bench and your feet flat on the floor; (3) Rest on the bench between lifts; (4) Be ready and give maximum effort; (5) Keep your hands over the tape on the bar; (6) No talking during the testing.

**Endurance Test**

The test consisted of the maximum number of
repetitions using eighty per cent of the subject's 1 R M as determined by his best strength post-test.

Endurance Test Instructions

The following instructions were given:

You have been assigned a weight according to your maximum press last week. The test today is to press the assigned weight as many times as possible. The score will be the number of times the weight is pressed. Some important points to remember: (1) Use proper technique (Touch chest, complete extension of the arms); (2) No resting or stopping during the exercise; (3) Do as many repetitions as you can; (4) Remember only one trial or set.

Testing Environment

All tests were conducted in the lobby of the gymnasium. Swinging doors separated the main gymnasium and the lobby. Two benches with barbells were used. A group of approximately ten in number were tested on a rotational basis. The groups were tested in the same order each time. The spotters were chosen from the group being tested. The investigator recorded all scores on the Individual Testing Record. Sample is in Appendix B. A card was devised which indicated the weight for each side of the barbell. This aided the spotters in the adjustment of weight for each subject. The investigator checked the final weight pressed for accuracy.
**Instrumentation**

The barbells used were standard five foot adjustable bars. Each bar was marked with two strips of tape three inches wide and twelve inches apart.

The benches were standard school benches sixteen inches in height and eleven inches in width. A plastic covered rubber mat was placed on top.

**Testing Barbells**

The bars and plates used in testing were weighed using a balance scale. The bars were equal in weight, twenty-four pounds and eight ounces. The plates used ranged in weight as follows: twenty-five pound plates with a zero to a plus two ounce variance, ten pound plates with a zero to a plus three ounce variance, five pound plates with a minus one to a plus two ounce variance, two and one-half pound plates with a zero to one pound variance, and one and one-quarter pound plates with a minus one ounce to a plus one ounce variance.

The slight variance in the weight of the plates was deemed insignificant in the light of the two and one-half pound intervals used in the testing program.

**Endurance Weight**

The endurance weight used was the computed
percentage of 1 R M to the nearest poundage to which barbells could be adjusted. There was a plus or minus one pound variance. This method allowed the smallest range of variance for the equipment used.

Design of Study

The study was twelve weeks in length. The first three weeks were designated pre-experimental and the fourth week was used for the pre-testing. The experiment was then conducted during the fifth through the tenth week for a total of six weeks. In-training tests were conducted during the sixth and eighth weeks. The post-testing was conducted during the eleventh week. The endurance tests were held during the twelfth week.

Pre-Experimental Phase

The pre-experimental phase of the study was conducted for three weeks. During this period the same exercise program was given to all the subjects. The exercises were conducted on Tuesday and Wednesday of the first week, Monday and Wednesday of the second week and Monday, Wednesday, and Friday of the third week. A test trial was conducted the first Friday and again on the second Friday. The strength gain after the second test trial was used to determine the bases on which the subjects were assigned.
Introduction to the Experiment

The experiment was introduced to the class on the first Tuesday by a ditto handout sheet. The ditto read as follows:

WEIGHT TRAINING STUDY

This class has been selected to participate in a twelve week weight training experimental study. The purpose of the study is to examine various methods of weight training using tenth grade students as subjects. The results of the study will be presented to San Fernando Valley State College in a Master's Thesis and to the Los Angeles City Board of Education.

Your attendance and complete cooperation during this study is most important. The weight training exercises will be conducted at the first part of the class period every Monday, Wednesday, and Friday and designated Tuesdays and Thursdays. At the conclusion of the study the class will continue its regular physical education activity.

The specific exercise to be used in the study will be the bench press exercise. This exercise develops the muscles of the shoulder girdle region.

For the duration of the study the following requests must be strictly observed: (1) No weight training outside the class; (2) No push-ups; (3) Maximum effort at all times.

Results and related information will be presented to the class after Christmas vacation. Additional information will not be available until that time.

The handout was read by the students as the instructor read it aloud. No other discussion or comments concerning the experiment were made throughout the twelve weeks.

Pre-Training Program

During the first week of the pre-experimental
period each subject trained with one set of ten repetitions.

Instructions for the First Training Session.—You will lie supine on the bench and put your feet flat on the floor. During the exercise you will keep your head and buttocks in contact with the bench and your feet on the floor. As the bar is placed upon your chest, grasp it with your hands over the tape. When you are ready to lift the weight say, 'O.K.,' and the spotters will let go of the bar. Then press the bar to full extension of the arms as many times as you can. At the completion of the exercise you will say, 'Take it,' and the bar will be taken by the spotters.

The instructions were repeated with a demonstration by the instructor.

Instructions for the Spotters.—There will be two spotters. One on each end of the bar. When you are spotting you are responsible for: (1) adjusting the weights; (2) checking the collar before each lift; (3) lifting the bar and placing the bar on the chest of the subject; (4) preventing the bar from falling on the subject by catching it; (5) placing the bar back on the mat after the exercise is completed.

The instructions were repeated with a demonstration by the instructor.

At the first training session an Individual Pre-Training Record card was given each subject with his name on it. See Appendix B for a sample. Each subject was instructed to write in the appropriate place the amount of weight he thought he could press ten times. The figure of fifty to sixty per cent of their body weight was given as a rough guide. The
subject was then instructed to record the number of repetitions completed following the exercise. Examples were given. The class was divided into three groups according to the weights to be used. Each group was assigned to a barbell and the individual exercise started. All scores were checked for eligibility and completion by the instructor as the record cards were returned.

At the beginning of the second session the investigator reviewed the training, the spotting techniques, and the recording procedures. The subjects were then divided into six groups according to the weight to be used. The available equipment permitted only three groups to train at any one time.

**Test Trial.**--On the first Friday a test trial was conducted. The test instruction and environment as described were used with the following changes. The initial weight for the test was determined by increasing the training weight used by twenty-five percent and rounding off the lowest five pound interval. Intervals of five pounds were used instead of two and one-half pounds. The test groups were divided according to the initial weight used in order to facilitate the testing procedure.

**Pre-Training Program.**--(Second Week). The second week of training was similar to the first week
as the investigator adjusted the weight after the training session. If a subject was absent the weights remained the same. The subjects trained on Monday, Wednesday, and Thursday.

**Preliminary Test.**--The preliminary test was given on Friday of the second week. The instruction and the conditions were as described. The test groups were divided according to the initial weight to be used.

**Pre-Training Program.**--(Third Week). The third week of training was similar to the second week. The subjects trained on Monday, Wednesday, and Friday.

**Pre-Tests**

Subjects who met experimental requirements were given two pre-tests, one on Tuesday and one on Thursday of the fourth week. Make-up tests were given on Wednesday for Tuesday and Friday for Thursday. The instructions and environment were as described. The subject's best score of the two tests was used as his pre-test score.

**Assignment of Subjects to Groups**

The subjects were randomly assigned to training groups according to strength gain between the preliminary test (Friday of Week 2) and the best of the
two pre-tests as determined by the Muller formula.

The Muller formula (18:304) for determining increase of strength is: \[
\text{Speed of Increase} = \frac{100}{W} \left(\frac{S_2}{S_1} - 1\right)
\]

where \(W\) equals the number of weeks of training, \(S_1\) equals the initial strength, and \(S_2\) equals the strength at training.

The subjects were placed in two divisions. One division had three training sessions between preliminary tests and the other trained twice. The divisions were created due to absenteeism of some subjects during one of the training periods. Both divisions were placed in rank order with the highest per cent first and the lowest last. Subjects of the first division were placed in experimental groups by the roll of the dice. Group I was assigned by the dice number one and four, Group II by numbers two and five and Group III by numbers three and six.

Starting with the highest subject in rank order, the first two subjects were assigned by this method and the third went to the remaining group. This was continued with each succeeding group of three subjects until all subjects for the division were assigned to groups. This was repeated for the second division.
Experimental Phase

Introduction to Subjects

All the subjects who met the requirements for the experimental groups were read the following information:

The class has been divided into three groups by random assignment. This means there has been no attempt at ability grouping. Since each of the three groups will have special tasks there will be no moving or trading from group to group. You will remain in the assigned group for the remainder of the experiment. Each group will train differently for the next six weeks. You will train only with your assigned persons.

The subjects were then divided into groups and given their individual instructions on training and recording on their Individual Training Records. See Appendix B for samples.

Experimental Training Programs

Group I.—Each subject of this group trained with three sets of six repetitions at maximum weight. The rest period was approximately two minutes between sets. The weights were adjusted according to the third set in which the subject executed as many repetitions as possible.

The initial weight for training was determined by subtracting five pounds from each subjects' pre-training weight. After the initial training session, the weights were increased five pounds when the subject could exercise beyond six repetitions. The weight was reduced similarly.
if the subject did less than four. This was used as a guide since individual variation made it impossible to use a definite plan. Every effort was made, however, to adjust the weight and keep the repetitions between four and six.

The following instructions were given to the subjects of Group I:

Each of you have been assigned to Group I. You will train with three sets of six repetitions. On the third set you are to do as many as you can. You will record the number of repetitions for each set on the Individual Training Record. Record only the number of repetitions on each set. The weight you will be using will be assigned each time by the instructor based upon your previous training record.

Important points to remember: (1) Use proper technique; (2) No resting or stopping during the exercise; (3) The first and second set—do six repetitions; (4) The third set—do as many as possible; (5) Record the number of repetitions you do each set; (6) Use the weight card to check that the proper weight is being used; and (7) Check collars before each lift.

Group II.—Each subject of this group trained with one set of six repetitions. The initial weight was determined by adding five pounds to each subject's preliminary training weight. After the initial training session the weights were then adjusted five pounds when the subject exercised beyond six repetitions or dropped below four. There were individual variations, but every attempt was made to adjust the weight to keep the
repetitions between four and six.

The following instructions were given to the subjects of Group II:

Each of you have been assigned to Group II. You will train with one set of maximum repetitions. This will be the same as pre-training except you will record the number of repetitions on the Training Record as you did before. The weight used will be assigned each time by the investigator based upon your previous training record.

Important points to remember: (1) Use proper technique; (2) No resting or stopping during the exercise; (3) One set do as many as you can; (4) Record the number of repetitions; (5) Use the weight card to check that the proper weight is being used; and (6) Check collars before each lift.

Group III.--Each subject of this group trained with their previous maximum (1 R M). If successful, five pounds were added until the exercise was unsuccessful. If the subject could not press his previous maximum, the spotters would give minimal assistance to complete the press. The initial weight was the same as used in each subject's best pre-test or reduced by two and one-half pounds.

The following instructions were given to Group III:

Each of you have been assigned to Group III. You will try for your maximum each time. You will attempt to lift the amount of weight assigned one time. If you are unable to complete the repetition the spotter will give minimal help. If you can lift the weight without help five pounds will be added and you will try again. This will be repeated until you are unsuccessful. The spotter will
assist you only with the first weight. Each
day you will have only one chance to lift each
amount of weight. You will record your training
on your Training Record. Write down each
weight you attempt and circle the highest
amount you lifted.

Important points to remember: (1) Use
proper technique; (2) Record each lift
attempted and circle the ones you lifted;
(3) Use the weight card to check that the
proper weight is being used; and (4) Check
collars before each lift.

A demonstration of "minimal help" was given.

Non-Experimental Training Group

The subjects who were not included in the experi-
mental groups continued the preliminary training program.

Training Sessions

Each group trained at the same designated area
throughout the experimental period. The equipment
facilities were set up before the subjects arrived for
practice. Group I used two bars and was located in the
lobby of the gymnasium. Group II used one bar and was
in the east corner of the gymnasium. Group III used one
bar and was along one wall approximately fifty feet from
Group II. The non-experimental group was in another
corner. There were two exceptions when circumstances
made it necessary for all groups to train in a different
location. During the training sessions the investigator
circulated among the groups emphasizing proper technique
and procedures.
In-Training Testing

On Thursday of the third and eighth week tests were conducted on all experimental groups in accordance with the test instructions and procedures. Makeup tests were given the Friday before training.

Post-Tests

Each subject was given two post-tests. These post-tests were given on Tuesday and Thursday of the eleventh week. The tests were conducted in accordance with the test instructions and procedures as described. Makeup tests were given on Wednesday for Tuesday and Friday for Thursday. The subject's best score of the two tests was used as his post-test score.

Strength Endurance Tests

On both Tuesday and Thursday of the twelfth week each subject was given strength endurance tests. Makeup tests were given on Wednesday and Friday. The tests were conducted in accordance with the testing procedures as outlined previously. The subject's best score was used as his strength endurance score.

Statistical Treatment

The data derived from the procedures outlined above were statistically analyzed to determine: (1) The reliability of the strength and strength endurance
measures, (2) The intra-group strength gain, (3) The differences of strength gains between each group, and (4) The differences in endurance between each group.
CHAPTER IV

ANALYSIS OF THE DATA

This study was designed to determine the effects of three methods of isotonic strength training on the development of strength and strength endurance. The data collected were analyzed statistically to determine these effects.

Analysis of the Data for Strength Gain

Group Differences

The subjects were placed into three groups in rank order according to their percentage of strength increase during the pre-experimental period. The differences between groups in strength increase for the pre-experimental period were determined by the \( t \) test. The data are reported in Table 1.

TABLE 1

Differences Between Means for Inter-group Pre-experimental Strength Increase

<table>
<thead>
<tr>
<th>Strength Gain</th>
<th>Difference</th>
<th>( t )</th>
</tr>
</thead>
<tbody>
<tr>
<td>Group I 4.3</td>
<td>Group II 5.9</td>
<td>1.6</td>
</tr>
<tr>
<td>Group II 5.9</td>
<td>Group III 4.6</td>
<td>1.3</td>
</tr>
<tr>
<td>Group III 4.6</td>
<td>Group I 4.3</td>
<td>0.3</td>
</tr>
</tbody>
</table>
The differences between groups in the pre-experimental strength gains were not statistically significant.

**Test Reliability**

Two reliability tests were conducted to determine the constancy of the measurement of strength. Each subject was given two pre-tests and two post-tests. The two pre-tests were compared with each other and the two post-tests were also compared. These reliability coefficients are reported in Table 2.

<table>
<thead>
<tr>
<th>Test</th>
<th>No. of Subjects</th>
<th>r</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pre-test</td>
<td>40</td>
<td>.94</td>
</tr>
<tr>
<td>Post-test</td>
<td>33</td>
<td>.99</td>
</tr>
</tbody>
</table>

**Intra-group Gain**

The intra-group gains are shown in Table 3. Group I—trained with three sets of six repetitions and had a mean gain of 13.9 pounds. This gain was found to be significant at the .01 level of confidence.
**TABLE 3**

Intra-group Strength Gain

<table>
<thead>
<tr>
<th>Group</th>
<th>Pre-test Mean</th>
<th>Post-test Mean</th>
<th>Mean Gain</th>
<th>t</th>
</tr>
</thead>
<tbody>
<tr>
<td>I</td>
<td>113.0</td>
<td>126.8</td>
<td>13.9</td>
<td>5.52*</td>
</tr>
<tr>
<td>II</td>
<td>98.1</td>
<td>103.1</td>
<td>5.0</td>
<td>2.78*</td>
</tr>
<tr>
<td>III</td>
<td>104.3</td>
<td>106.3</td>
<td>2.0</td>
<td>2.50**</td>
</tr>
</tbody>
</table>

*.01 level of confidence
**.05 level of confidence

Group II--trained with one set of six repetitions and had a mean gain of 5.0 pounds. This gain was also found to be significant at the .01 level of confidence. Group III--trained with a single maximum repetition and had a mean gain of 2.0 pounds. This gain was significant at the .05 level of confidence.

**Inter-group Comparison**

The inter-group comparisons are shown in Table 4.

**TABLE 4**

Inter-group Strength Gain

<table>
<thead>
<tr>
<th>Strength Gain</th>
<th>Difference</th>
<th>t</th>
</tr>
</thead>
<tbody>
<tr>
<td>Group I 13.9</td>
<td>Group III 2.0</td>
<td>11.9</td>
</tr>
<tr>
<td>Group I 13.9</td>
<td>Group II 5.0</td>
<td>8.9</td>
</tr>
<tr>
<td>Group II 5.0</td>
<td>Group III 2.0</td>
<td>3.0</td>
</tr>
</tbody>
</table>

*.01 level of confidence
The inter-group gains were 13.9, 5.0, and 2.0 for Groups I, II, and III respectively. Group I was significantly better than Group II and III at the .01 level of confidence. There was no significant difference between Groups II and III.

**Analysis of Data for Strength Endurance**

**Test Reliability**

A reliability test was conducted to determine the constancy of strength endurance. Each subject was given the strength endurance test twice during the twelfth week. The reliability coefficient for strength endurance is reported in Table 5.

**TABLE 5**

<table>
<thead>
<tr>
<th>Number of Subjects</th>
<th>r</th>
</tr>
</thead>
<tbody>
<tr>
<td>30</td>
<td>.78</td>
</tr>
</tbody>
</table>

**Inter-group Strength Endurance Comparison**

A test for strength endurance was conducted. There were no significant differences between the groups. The inter-group differences for strength endurance are
reported in Table 6.

### TABLE 6
Inter-group Strength Endurance Comparison

<table>
<thead>
<tr>
<th>Endurance</th>
<th>Difference</th>
<th>t</th>
</tr>
</thead>
<tbody>
<tr>
<td>Group I 10.3</td>
<td>Group II 11.7</td>
<td>1.4</td>
</tr>
<tr>
<td>Group II 11.7</td>
<td>Group III 10.3</td>
<td>1.4</td>
</tr>
<tr>
<td>Group I 10.3</td>
<td>Group III 10.3</td>
<td>0.0</td>
</tr>
</tbody>
</table>

**Summary of Findings**

1. The reliability coefficient of the subject's test and retest of strength for the pre-test was .94 and the post-test .99.

2. Significant intra-group strength gains were recorded for Groups I and II at the .01 level of confidence and Group III at the .05 level of confidence.

3. Group I had a strength gain that was significantly better than that of Group II and III at the .01 level of confidence. There was no significant difference between Groups II and III.

4. The reliability coefficient of the test and retest of strength endurance was .78.
5. There were no significant differences between the groups in strength endurance.
CHAPTER V

DISCUSSION OF THE FINDINGS

This study was undertaken to determine the effects of three isotonic training techniques on the development of strength and strength endurance. This chapter includes a discussion of the variables of the study, the interpretation of the findings relative to strength gain and the interpretation of the findings relative to strength endurance.

The Control of Variables

In a study of this nature the significance of the findings depends upon the extent that the variables affecting human behavior can be identified and controlled.

Equating Groups

Many strength studies can be criticized for their method of assigning subjects to groups. In the studies by Berger, for example, the subjects were enrolled in college weight training classes. The experimental groups were assigned on a class basis rather than a random assignment of subjects to the experimental variables; the assumption being that the classes were similar. It would appear that a more controlled method of equating groups
Muller (18:304) found that the rate of increase in strength decreases as a subject approaches his theoretical maximum strength. In order to equalize varying groups each group should have an equitable number of subjects with varying degrees of potential strength gain. In this study Muller's formula was used for determining strength increase and subjects were placed in rank order according to percentage of strength gain and randomly assigned to groups. The statistical analysis of these percentages show that no significant differences existed between groups prior to the experimental phase of the investigation.

Loss of Subjects

There were sixty-one students enrolled in class at the beginning of the study. Twenty-one were dropped from the study during the pre-experimental period. Nineteen were eliminated for absenteeism and two others were unable to participate due to injuries.

Forty subjects were assigned to groups. Group I had fourteen subjects and Groups II and III each had thirteen. During the first week of training students who desired to take Driver's Training left their Physical Education period for six weeks. Group II lost three subjects and Group III lost one subject to Driver's
Training.

Two subjects from Group I transferred schools during the experimental period and one subject was dropped for absenteeism.

Group II and Group III each lost one subject for absenteeism and one subject from Group III had to be dropped due to a broken hand.

The loss of ten subjects resulted in thirty subjects completing the strength part of the study. Two subjects missed one or more strength endurance tests dropping the total number of subjects for this phase to twenty-eight. The investigator planned on fifteen members per group for statistical analysis. The loss of 50 per cent of the original subjects was not predictable.

The Task

In this study the pre-test reliability was .94 and the post-test was .99. The difference between these figures was probably caused by better testing environment for the second test. The pre-test conditions may have been influenced by psychological factors such as environment and instructor anxiety. Ikai and Steinhaus (13) have demonstrated that certain outside factors could significantly influence maximum strength scores.

The coefficient of correlation found for the test,
retest of strength endurance was .78, which seems to be low, considering the strength coefficient of correlation. During one of the tests the Girl's Drill Team was using the gymnasium and the subjects watched the girls before they took their test in the lobby. This may have influenced the subjects' concentration, motivation, or readiness for the task.

Another influencing variable which was found to affect strength measurement was reported by Hood and Forward (12). They found that maximum strength significantly increased from week to week for the first three weeks without training. This phenomenon was attributed to a learning factor. During the pre-experimental period of this investigation increases in strength resulting from familiarization of equipment should have occurred before the experimental period began, thus eliminating a possible early learning factor from the experimental data.

**Strength Gain**

**Group I**

This group trained with three sets of six repetitions. There was a significant gain of 13.9 pounds for the six weeks of training, an increase of 12 per cent. Berger (4:168) reported that a similar training method with college weight training subjects had a gain of 23.6
pounds for six weeks of training or an increase of 19 per cent. Although the method of this study and Berger's are similar the general design and subjects are different. One of the major differences in the average gain between the two studies is probably due to a lack of a pre-experimental period (familiarization) in Berger's study.

**Group II**

This group used one set of six repetitions per training session and showed a significant gain of 5.0 pounds, or an increase of 5 per cent. Berger reported a gain of 18.4 pounds or 14 per cent for similar training with college weight training subjects (4:168). This is almost three times better than the high school group. The factors discussed for Group I may have contributed to this difference.

**Group III**

This group used a single repetition and had a gain of 2.0 pounds or 2 per cent. Berger (4) found a set of two repetitions had a significant gain of 17.1 pounds or 14 per cent in six weeks of training. In another study (3) in which the 1 RM was employed Berger found a significant strength gain at the .01 level of confidence after six weeks of training using the leg press.
The first program of two sets of two had twice the repetitions or work load as that of Group III. The second study used another muscle group which may possibly have produced different training effects for similar training.

Another possible explanation is that the subjects assumed they had reached their maximum performance after trying 1 R M for several training sessions. Group III had seven opportunities to try 1 R M between the pre-test and the In-Training Test 1. By that time their repeated failures impeded the improvement of performance.

**Inter-group Differences**

Group I, the three set group, was significantly better than Group II and III. Berger (5:176) found that three sets of six was significantly better at the .05 level of confidence than one set of six. Berger did not compare 1 R M training to varying numbers of sets and repetitions. Possible explanation of these differences can be proposed. The three set group did more work than the other two groups, therefore gained more strength. The first two sets may have served as a physiological and psychological warmup for the individual optimum performance on the third set. Many athletes find that specific warmup, executing their competitive movement helps their performance. Another factor may be the number of
repetitions at near maximum overload in the three sets that creates a sufficient degree of stress to increase the physiological adjustment. This adjustment may include influence of the proprioceptors on the central nervous system besides the physiological phenomenon.

**Strength Endurance**

The analysis of the data indicated no significant differences between groups for the strength endurance test. The variation of plus or minus one pound in weight used in the test exercise compared to the computed weight (80 per cent of 1 R M) could have affected the results.

The means for the three groups were 10.3, 11.7, and 10.3 for Groups I, II, and III respectively. Therefore the maximum repetition with 80 per cent of 1 R M roughly approximates 10 R M.

Barney and Bangerter (1) in a study described in the review of literature used 1 R M and 10 R M for tests of strength. The 1 R M test showed no significant difference between groups. The 10 R M test showed significant differences. The Barney and Bangerter technique was not similar to the present study's techniques, therefore, no comparison could be made.

Berger and Harris (6) used different techniques with a 1 R M test and maximum repetitions with 50 per cent of initial 1 R M as described in the review of the
literature. There were no significant differences between groups using either test.

Each of the above studies and this study used three different techniques or a total of nine different techniques. Only Barney and Bangerter found significant differences using a strength endurance test. Further investigation is needed to confirm that the modified DeLorme technique is the best technique for the development of strength endurance.
CHAPTER VI

SUMMARY, FINDINGS, CONCLUSIONS, AND RECOMMENDATIONS

Summary

This study was designed to investigate the effects of three isotonic training programs on the development of strength and strength endurance of tenth grade high school boys. The specific body area involved was the elbow extensors as used in the bench press exercise. The three training programs were:

(1) Training with three sets of six repetitions at maximum weight; (2) Training with one set of repetitions at maximum weight; and (3) Training using a single repetition at maximum weight.

Strength was determined by 1 R M isotonic bench press (one repetition at maximum overload). Strength endurance was determined by a test of maximum repetition using 80 per cent of 1 R M on the isotonic bench press.

Forty subjects were randomly assigned to groups based on initial strength gain as determined by Muller's formula. Ten subjects were dropped for failure to meet the requirement of the investigation.
The design of the twelve week study was as follows: Pre-experimental or familiarization phase three weeks; Strength pre-tests one week; Experimental phase six weeks; Strength post-test one week; and Strength Endurance tests one week. Training sessions were conducted on Monday, Wednesday, and Friday throughout the study. During the pre-experimental phase all subjects trained with one set of repetitions at maximum weight. Each subject was given two pre-strength tests and assigned to one of the three experimental training programs. At the conclusion of the training program two post-strength tests and two strength endurance tests were conducted.

Findings

1. That Group I and Group II had a significant strength gain at the .01 level of confidence. Group III had a significant strength gain at the .05 level of confidence.

2. That Group I was significantly better than Group II and III in strength gain at the .05 level of confidence. There was no significant difference between Group II or III.

3. No significant differences were found in strength endurance between the groups.
Conclusions

The findings of this study reject the first null hypothesis; that no differences exist in the training effects on strength using the three methods of isotonic training as described in this investigation.

The second null hypothesis is tenable; that no differences exist in the training effects on strength endurance using three methods of isotonic training as described in this investigation.

Recommendations

Further investigation into the effects of isotonic training on strength and strength endurance is indicated by this study. The following recommendations are suggested: (1) Further investigation is needed to determine the best technique to develop strength endurance, and (2) An investigation comparing the best strength and strength endurance techniques on the development of strength and strength endurance.
BIBLIOGRAPHY
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