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The Effects of Three Selected Weight Training Programs on Muscular Strength, Endurance Girth, and Cardiovascular Endurance

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THE EFFECTS OF THREE SELECTED WEIGHT TRAINING PROGRAMS ON MUSCULAR STRENGTH, ENDURANCE GIRTH, AND CARDIOVASCULAR ENDURANCE

BY

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This thesis is approved as a creditable and independent investigation by a candidate for the degree, Master of Science, and is acceptable as meeting the thesis requirements for this degree, but without implying that the conclusions reached by the candidate are necessarily the conclusions of the major department.

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Abstract

LESLIE CURTIS HANSEN

Under the supervision of Dr. Paul H. Brynteson
and Associate Professor Glenn E. Robinson

The purpose of this investigation was to compare the effects of three different weight training programs on the development of muscular strength, muscular endurance, muscular girth, and cardiovascular endurance. Thirty freshman and varsity football players from the 1968 South Dakota State University football teams were used as subjects. The subjects were randomly divided into three different groups. One group trained using a modification of the DeLorme-Watkins method of training; the second group followed the traditional strength training method, while the third followed a circuit training program.

The conditioning programs for the three groups consisted of ten exercises: bench press, military press, two arm curl, erect rowing, lat exercise, sit-up, bent rowing, leg press, heel raisers, and dead lift.

Training covered a period of seven weeks, with the subjects meeting on Monday, Wednesday, and Friday for twenty-one training sessions. Tests for muscular strength, endurance, and girth were administered before the program began, at the end of three weeks of training, and at the conclusion of the training program. Cardiovascular endurance was determined and data were recorded at the beginning and at the end of the training program. Two weeks separated the initial test and the start of the program because of the semester break.

Within the limitations of this study, the following conclusions were made:

1. The three training programs used for this study all improved strength, muscular endurance, girth, and cardiovascular endurance.
2. The modified DeLorme-Watkins, traditional strength, and circuit training programs produced basically the same results for muscular strength, endurance and girth; however, the circuit training program produced the best results for cardiovascular endurance.
3. Since the three methods of weight training produced basically the same results, the investigator suggests the use of circuit training for the development of physical fitness due to the shorter period of time required to complete the daily training program.

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THE PROBLEM, LIMITATIONS, AND DEFINITIONS OF TERMS USED

CHAPTER I

THE PROBLEM, LIMITATIONS, AND DEFINITIONS OF TERMS USED

Weight training programs have become an accepted and often prescribed off-season method of conditioning by many athletes and coaches. The basic goal of progressive resistance weight training is the development of strength. Morehouse and Rasch state that when man competes against man, the stronger individual possesses an advantage.[1] Muscular endurance and cardiovascular endurance are added to muscular strength to form the basic elements of physical fitness.[2]

Many studies discuss training programs as related to muscular strength, endurance, and girth. In regard to weight lifting Massey, et. al. state:

> Weight lifting, however, does not produce tremendous changes in the cardio-respiratory system . . . Systematic weight training has little effect on overall bodily endurance as controlled by the heart rate, stroke volume, depth of breathing, and respiratory rate. The exercises are not carried out continuously over a long enough period of time to affect these factors.[3]

Advocates of circuit training claim that their method of training will improve cardiovascular endurance as well as improve strength

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[1]Laurence E. Morehouse and Philip J. Rasch, Scientific Basis of Athletic Training (Philadelphia: W. B. Saunders Company, 1958), p. 108.

[2]H. Harrison Clarke, Application of Measurement to Health and Physical Education (Englewood Cliffs, New Jersey: Prentice-Hall, Inc., 1967), p. 202.

[3]Benjamin H. Massey, et. al., The Kinesiology of Weight Lifting (Dubuque: Wm. C. Brown Company, 1959), p. 58.

and muscle endurance.[4] The investigator was concerned with the development of cardiovascular endurance in addition to the variables of strength, muscular endurance, and girth by the use of different methods of progressive resistance exercise.

I. THE PROBLEM

Statement of the problem. The purpose of this investigation was to compare the effects of three different weight training programs on the development of muscular strength, muscular endurance, muscular girth, and cardiovascular endurance.

Importance of the study. The literature reveals many isolated studies indicating that weight training exercises have effectively improved the physical condition of individuals. Proponents of different types of training programs claim their method to be superior in the development of one or two components of physical fitness. The following question arises: Is there any one method of training which is superior to the other methods in the general development of a combination of components of physical fitness? Usually the effect of one or two training methods on one or two variables has been investigated, but the writer felt that a broader investigation employing three methods of training and their influence on the three variables of physical fitness plus muscular girth would be of value to the profession.

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[4]Robert P. Sorani, Circuit Training (Dubuque: Wm. C. Brown Company, 1966), p. 2.

II. LIMITATIONS OF STUDY

1. The study was limited to thirty members of the 1968 freshman and varsity football teams at South Dakota State University.
2. No attempt was made to regulate sleep, diet, or living habits of the subjects during the study.
3. The training program lasted for seven weeks.
4. Data were collected on only three occasions: at the beginning of the training program, after three weeks of training, and at the conclusion of the program.
5. Previous weight training experience of the subjects was not considered in the program.

III. DEFINITION OF TERMS USED

Muscular strength. The ability of muscle tissue to exert a force in a single muscular contraction.

Muscular endurance. The ability to continue muscular exertions of submaximal magnitude.

Muscular girth. The size or maximum circumference of the upper arm.

Cardiovascular endurance. The ability of the circulatory-respiratory systems to make adjustments to moderate contractions of

the body's large muscle groups over a period of time.[5]

Physical fitness. The ability to carry out daily tasks with vigor and alertness, without undue fatigue, and with ample energy to enjoy leisure-time pursuits and to meet unforeseen emergencies.[6] The basic physical fitness elements are muscular strength, muscular endurance, and circulatory endurance.[7]

Repetition. The performance of a single movement from the start through its full range and back again to the starting point.

Set. A specified number of continuous repetitions.

Target time. The time in which the circuit must be completed before progressing to a more strenuous level in circuit training.

One repetition maximum (1 RM). The maximum weight which can be lifted one time.

Six repetition maximum (6 RM). The maximum weight which can be lifted six times.

Modified DeLorme-Watkins method. A method of weight training consisting of three sets of six to eight repetitions. The first set consists of one-half the six RM. The second set employs six repetitions using three-fourths the six RM, and the third set uses the six RM.

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[5]Herbert A. de Vries, Physiology of Exercise for Physical Education and Athletics (Dubuque: Wm. C. Brown Company, 1966), p. 332.

[6]Clarke, op. cit., p. 14.

[7]Ibid., p. 202.

Traditional strength method. A weight training procedure using three sets of six to eight repetitions. The weight used for each set is the six RM. This method is referred to as the MacQueen Method of weight training.

Circuit training. A method of weight training that purports to increase muscular strength, endurance, and cardiovascular endurance by adding a time factor to the overload principle of the traditional weight training programs. The term "circuit" refers to a number of carefully selected exercise stations arranged consecutively, about a given area. Each station within the circuit is arranged to allow the subjects to progress easily and quickly from one station to another, doing a prescribed amount of work.[8]

Training dose. One-half the maximum number of repetitions which could be performed in thirty seconds.

IV. HYPOTHESIS

There is no significant difference among the three methods of weight training relative to the development of muscular strength, muscular endurance, muscular girth, and cardiovascular endurance.

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[8] Sorani, loc. cit.

CHAPTER II

REVIEW OF THE LITERATURE

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REVIEW OF THE LITERATURE

The value of weight training has been relatively well established by studies which have indicated that weight training improves strength and fitness of man. The results of these studies have led to the use of weight training by athletes in off-season training programs. There have been numerous studies on weight training, including circuit training, whose results indicate significant gains in strength and muscular endurance; however, there have been few studies comparing circuit training with the traditional methods of training in improving the various components of physical fitness.

The following observation was made by Lawther about strength training:

> Extensive development of strength seems to be possible for most individuals. Strength is best developed through exercise against gradually increasing resistance; that is to say, the intensity of the work, instead of its duration, should increase . . . Weight training is a use of systematic exercises, with weights used merely as the means to increase resistance to muscle contractions.[9]

de Vries writes that when strength and hypertrophy are objectives of weight training, they are achieved by performing exercises at maximal loads. One of the outward manifestations of strength is the development of large firm muscles. The literature indicates that there is a positive correlation between strength and muscle girth;

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[9]John D. Lawther, Psychology of Coaching (Englewood Cliffs, New Jersey: Prentice Hall, Inc., 1955), pp. 258-259.

however, the relationship is not absolute. The correlation is quite small for groups who are obese or untrained.[10] McGovern and Liscomb also write that a high repetition, low resistance exercise program increases endurance but not bulk; in fact, bulk may be diminished by this regimen.[11] However, Massey, et. al. feel that all individuals do not achieve the same degree of hypertrophy while following the same weight training program.[12]

A normative study of Big Ten swimmers conducted by Sloan indicated that there appears to be an association between those teams consistently ranked in the upper division and the amount of off-season training. Those teams doing less work during the off-season ranked consistently in the lower division. Along with the off-season swimming activities, almost 65 per cent of the swimmers used some form of weight training program.[13]

Karpovich states that even though muscle training has been practiced since time immemorial, and obviously with remarkable success,

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[10]Herbert A. de Vries, Physiology of Exercise for Physical Education and Athletics (Dubuque: Wm. C. Brown Company, 1966), p. 303.

[11]R. E. McGovern and H. B. Liscomb, "Useful Modifications of Progressive Resistance Exercise Technique," Archives of Physical Medicine and Rehabilitation, 34:475-477, August, 1953.

[12]Benjamin H. Massey, et. al., The Kinesiology of Weight Lifting (Dubuque: Wm. C. Brown Company, 1959), p. 57.

[13]Richard H. Sloan, "An Analysis of 1965 Off-Season Training Regimes of Big Ten Swimmers" (unpublished Master's thesis, The University of Illinois, Urbana, 1966), pp. 1-53.

one may be surprised to discover that even now there is no complete agreement as to the best method for muscle training.[14]

I. LITERATURE ON DELORME-WATKINS METHOD

DeLorme and Watkins write that in their initial publications concerning progressive resistance exercise, they advocated 70 to 100 repetitions performed in seven to ten sets with ten repetitions per set. Upon further study DeLorme and Watkins now prescribe three sets of ten repetitions each. The first set of ten repetitions are performed with one-half the ten RM, the second with three-fourths the ten RM, and the third set with the ten RM. Three sets of exercises in which the resistance was increased after each set offered the advantage of warming up the muscle but it probably did not contribute toward increasing the muscle strength more than one set of the maximum ten RM.[15]

Asa, in studying the effects of isometric and isotonic exercises on the strength of skeletal muscles, divided the subjects into two groups. One group of six used the DeLorme method of training and the other group of twelve used isometric exercises. The abductor digiti quinti muscle was exercised daily for twelve weeks. Both groups were tested for isotonic and isometric strength with no significant

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[14]Peter V. Karpovich, Physiology of Muscular Activity (sixth edition; Philadelphia: W. B. Saunders Company, 1965), p. 25.

[15]Thomas L. DeLorme and Arthur L. Watkins, Progressive Resistance Exercise (New York: Appleton-Century-Crofts, Inc., 1951) pp. 24-28.

difference resulting between the groups.[16]

The study by Barney and Bangerter compared the DeLorme-Watkins, Traditional Strength, and Traditional Power methods of weight training for the development of strength and muscle girth. The results of the study indicated that there was no significant difference among the three methods in the development of strength; however, the DeLorme-Watkins method was significantly better at the .05 level than either the Traditional Strength or Power methods in the development of muscle girth.[17]

In studying progressive resistance exercises in cup arthroplastics of the hip, DeLorme used subjects that lacked adequate muscular support of the hip. Using the DeLorme-Watkins method of training, muscle strength substantially improved in one to three months except where hindered by pain, lack of cooperation, or firmly rooted habit patterns.[18]

In another study DeLorme observed the effect of heavy resistance exercises on the restoration of weakened and atrophied quadriceps muscles on 300 subjects. In several cases two to two and one-half

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[16]Maxim M. Asa, "The Effects of Isometric and Isotonic Exercises on the Strength of Skeletal Muscle" (unpublished Doctoral Dissertation, Springfield College, Springfield, 1959), pp. 11-116.

[17]Vermon S. Barney and Blauer L. Bangerter, "Comparison of Three Programs of Progressive Resistance Exercises," The Research Quarterly, 32:138-146, May, 1961.

[18]Thomas L. DeLorme and Arthur L. Watkins, "Progressive Resistance Exercises in Cup Arthroplastics of the Hip," Archives of Physical Medicine, 30:367-374, October, 1949.

inches of hypertrophy were observed after six to eight weeks of exercise, and significant gains in muscle power were noted in all cases.[19]

In their book concerning progressive resistance exercise, DeLorme and Watkins state:

> Athletics, even the most strenuous variety, do not produce muscular strength of the same degree as do focal progressive resistance exercises. This has been shown repeatedly in quadriceps redevelopment in young football players and trackmen. Even the fastest and most powerful of linemen after several years of football have been able to increase quadriceps strength from 50 to 100 per cent in six to eight weeks of progressive resistance exercise.[20]

II. LITERATURE ON TRADITIONAL STRENGTH METHOD

Greenwood studied the effects of the traditional strength training program on muscular strength and trunk flexion. The training program lasted for six weeks with the subjects meeting on Monday, Wednesday and Friday. Ten exercises using three sets of eight to twelve repetitions were employed in the study. Results of the study indicated a significant gain in strength, as measured by the Rodgers Physical Fitness Index and Larson Strength Test, along with a gain in

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[19] Thomas L. DeLorme, "Restoration of Muscle Power by Heavy Resistance Exercise," The Journal of Bone and Joint Surgery, 27:645-667, October, 1945.

[20] DeLorme and Watkins, op. cit., p. 132.

trunk flexion, as measured by the Iowa Test of Motor Fitness.[21]

Helixon, in studying the effects of progressive heavy resistance exercises on running and jumping ability, divided subjects into two groups. The control group was not involved in any formal exercise program. The experimental group followed a six weeks training program which met three days per week. The training program consisted of three sets of eight to twelve repetitions on the half squat, arm press, and arm curl. Subjects were tested initially, at the end of two, four, and six weeks, and one week after the training program was completed. The results of the study indicated that the training program did not produce a significant effect upon the performance of the experimental group as compared to the control group.[22]

Berger studied the effects of traditional training programs using: (1) three sets and two repetitions, (2) three sets and six repetitions, and (3) three sets of ten repetitions on the development of strength. Strength was measured by knee extension and was tested for both static and dynamic strength. The results of the study indicated that all programs significantly increased strength; however,

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[21] David H. Greenwood, "The Effect of A Weight Training Program Upon Strength and Trunk Flexion of Football Players at South Dakota State College" (unpublished Master's thesis, South Dakota State College, Brookings, 1961), pp. 16-39.

[22] Patric J. Helixon, "The Effects of Progressive Heavy Resistance Exercises Using Near-Maximum Weights on the Running and Jumping Ability of First Year High School Track Performers" (unpublished Master's thesis, Michigan State University, East Lansing, 1956), pp. 1-61.

no significant difference between the three treatments was noted.[23]

Walters applied two different variations of the traditional strength training treatments to the curl and bench press in an attempt to determine the relative effectiveness of weight training programs using high and low repetitions in the development of muscular strength and endurance of the arms. One treatment consisted of ten to twelve repetitions per set, and the other treatment incorporated twenty to twenty-two repetitions per set. Strength was measured by the maximum weight lifted through one repetition, while endurance was measured by the maximum number of repetitions possible using one-half of the weight established by the strength test. The results of the study indicated that ten to twelve repetitions were significantly better than twenty to twenty-two in measurements of endurance and strength for the curl, but there was no statistical difference in strength developed by the bench press between the two groups.[24]

In another study by Berger, nine different traditional programs were tested for the development of strength and endurance. The programs varied from two to ten repetitions and from one to three sets. The results of the study indicated that all programs showed a

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[23]Richard A. Berger, "The Effects of Selected Programs of Progressive Resistance Exercise on Strength, Hypertrophy, and Strength Decrement" (unpublished Master's thesis, Michigan State University, East Lansing, 1956), pp. 1-56.

[24]B. R. Walters, "The Relative Effectiveness of High and Low Repetitions in Weight Training Exercise on Strength and Endurance of the Arms" (unpublished Master's thesis, The University of Iowa, Iowa City, 1949), pp. 12-21.

significant improvement in strength; however, three sets were significantly better than either one or two sets in the development of endurance. There was no significant difference in strength gained between the different number of repetitions.[25]

Capen studied 149 male students in a study of four traditional weight training programs on the development of strength. The subjects were divided into four groups: (1) one set of eight to fifteen repetitions, (2) one set of eight to fifteen repetitions and a second set of five repetitions, (3) three sets of five repetitions, and (4) three sets employing only one repetition per set. The subjects were further divided into groups lifting three times and five times per week. Results of the study indicated that there was no significant difference between the groups when comparing repetitions and sets. Training three times per week was significantly better in the development of strength than training five times per week for the group using three sets of the five RM.[26]

The effect of isometric exercises, the traditional weight training method employing three sets of five repetitions, and subjects taking part in regular physical education classes were tested by

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[25]Richard A. Berger, "The Effect of Varied Weight Training Programs on Strength and Endurance" (Doctor of Philosophy dissertation, The University of Illinois, Urbana, 1960), pp. 26-28.

[26]Edward Capen, "Study of Four Programs of Heavy Resistance Exercise for Development of Muscular Strength," The Research Quarterly, 27:154-157, May, 1963.

Rallis for muscular endurance of the arms and legs. The tests used to determine endurance were the maximum number of push-ups completed in one minute for arm endurance and the number of squat jumps in one minute for leg endurance. Both groups employing weight training and isometric contractions were significantly better than subjects enrolled in physical education classes in developing endurance; however, the difference between groups employing weight training and isometric contractions was not significant.[27]

Berger has also studied the effects of programs of two, four, six, eight, ten and twelve repetitions on the development of strength. The test used at the beginning and end of the program to determine strength was to lift the maximum weight possible through one repetition of the bench press. The results of the study indicated that all of the programs significantly improved strength but weight training programs using between three and nine repetitions were better for the improvement of strength.[28]

Rasch and Morehouse observed the effects of a six-week program of isotonic and isometric exercises on forty-nine male subjects. The training program of the isotonic group consisted of a Monday-Wednesday-Friday exercise period using three sets of five repetitions for the

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[27]Socrates Rallis, "A Comparison of Three Training Programs and Their Effects on Five Physical Fitness Components" (unpublished Master's thesis, Wayne State University, Detroit, 1965), pp. 32-102.

[28]Richard A. Berger, "Optimum Repetitions for the Development of Strength," The Research Quarterly, 33:334-338, October, 1962.

curl and military press. The weight that each subject used was the five RM established at the beginning of the program. Work loads were increased as the subjects improved in strength. The isometric program consisted of three sets of two-thirds maximum contraction for fifteen seconds with a three minute rest period between sets. The subjects were measured for strength gain by the use of the strain gauge dynamometer. The isotonic groups increased strength at the .01 level of confidence for the press and curl, while the isometric group did not reach this level. Muscular girth of the upper arm was measured by a steel tape employing the flexed arm method. Data were recorded to the nearest .01 centimeter. The results indicated a significant gain at the .01 level of confidence for the isotonic group but not for the isometric group.[29]

III. LITERATURE ON CIRCUIT TRAINING

Advocates of circuit training emphasize the short period of time required to complete the training period as an advantage over the traditional weight training programs. In regard to the time spent in the actual lifting of weights, Karpovich asserts that although a weight lifting session may last from one to two hours, the time actually spent on lifting may be only two to six minutes.[30]

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[29]Philip J. Rasch and Laurence E. Morehouse, "Effect of Static and Dynamic Exercises on Muscular Strength and Hypertrophy," Journal of Applied Physiology, 11:29-34, July, 1957.

[30]Karpovich, op. cit., p. 27.

Howell, Hodgson, and Sorenson equated thirty-four subjects into groups of seventeen using the Modified Harvard Step Test. The experimental group participated in circuit training twice per week for four weeks. The control group took part in the regular service program consisting of volleyball and badminton. At the conclusion of the program, the subjects were retested on the Modified Harvard Step Test. The group participating in circuit training showed a statistically significant improvement on the retest while the control did not. The results on the retest between the two groups were not significant.[31]

Simmons compared the effects of circuit training and a physical conditioning program on physical fitness and motor performance of subjects. The circuit training group trained for thirty minutes twice weekly for ten weeks. The subjects in the conditioning program trained for the same amount of time. Administered to the subjects were a pretest and post test consisting of a fifteen-item physical fitness battery and a thirteen-item motor performance test. The results of the survey indicated that both groups improved in fitness. The conditioning program was superior in improving general conditioning while circuit training was superior in improving motor performance and local endurance.[32]

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[31] Maxwell L. Howell, James L. Hodgson and Thomas J. Sorenson, "Effects of Circuit Training on the Modified Harvard Step Test," The Research Quarterly, 34:154-157, May, 1963.

[32] Robert Simmons, "The Effect of Circuit Training Upon Cardiovascular Condition and Motor Performance" (unpublished Master's thesis, The University of Washington, Seattle, 1965), pp. 29-132.

Maroc compared the effects of: (1) ten minutes of circuit training, (2) twenty minutes of circuit training, and (3) fifteen minutes of progressive body conditioning exercises on five components of physical fitness. The tests used to evaluate the program were the Illinois Agility Run, modified push-ups, toe touch, curl-up, and squat thrust. The results of the testing indicated that both circuit training programs produced significantly better results than the conditioning program in the areas of flexibility, endurance, abdominal strength and endurance, and the total fitness level.[33]

Nunney studied the effects of circuit training on six areas of fitness using members of an intermediate swimming class. The training period consisted of three thirty-minute meetings per week for six weeks. A control group performed only those activities used in the regular swimming class. The program for the experimental group consisted of thirty minutes of swimming on Monday, and ten minutes of swimming plus fifteen minutes of circuit training on Wednesday and Friday. The subjects were tested for improvement in swimming endurance and speed, chins, dips, push-ups, weight, and the vertical jump. The experimental group made statistically significant gains in body weight, swimming endurance and speed, chins, and push-ups. The circuit training class was significantly better than the swimming class

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[33]Donna Jean Graham Maroc, "The Effect of Two Programs of Circuit Training on the Physical Fitness of College Women" (unpublished Master's thesis, The University of Washington, Seattle, 1965), pp. 54-117.

in body weight gain and chins.[34]

Brown studied the effects of circuit training on forty-nine fifth grade girls. The subjects were divided into groups with twenty-five in the experimental group and twenty-four in the control group. The experimental group performed ten minutes of circuit training at the beginning of each class period and devoted the remainder of the period to the regular class activities. The control group participated in the regular physical education activities without the circuit training program. Both groups made statistically significant gains on their test scores. There was no significant difference between group mean gains.[35]

Hodgson compared the effects of circuit training and isometric exercise on treadmill performance using forty-five freshmen male subjects. The circuit training group traversed a ten-minute circuit followed by twenty-five minutes of regular physical education activities. The subjects, using isometric exercises, performed a similar program using ten minutes of isometric exercises followed by twenty-five of regular class activities. A control group participated only in the regular physical education class of badminton which lasted for thirty-five minutes. The Balke Treadmill Test was used to

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[34]D. R. Nunney, "The Relation of Circuit Training to Swimming," The Research Quarterly, 31:188, May, 1960.

[35]Annis May Brown, "The Effect of Circuit Training on the Physical Fitness of Grade 5 Girls" (unpublished Master's thesis, University of British Columbia, Vancouver, 1961), pp. 22-56.

determine treadmill performance. The results of the Balke Test employing test-retest procedures indicated that all three groups improved their performance at the .01 level of confidence. Circuit training was significantly better than isometric training; however, neither circuit training nor isometric training was significantly better than the regular physical education activities in improving treadmill performance time.[36]

Taylor studied the effect of circuit training upon cardiovascular and muscle status of forty-two businessmen. The subjects were divided into two groups for eight weeks of training with one group following a program of calisthenics and the other a circuit training program. The Larson Muscular Strength Test and the Harvard Step Test were administered as a pretest and post test to record gains in strength and cardiovascular fitness. The results of the study indicated that both training programs produced significant gains in strength and cardiovascular fitness; however, there was not a significant difference between the results for the two training methods.[37]

The effect of four methods of circuit training on the improvement of physical condition were observed by Undlin. The subjects were

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[36]James Lea Hodgson, "The Effect of Circuit Training and Isometric Exercises on Treadmill Performance" (unpublished Master's thesis, University of Alberta, Edmonton, 1963), pp. 1-71.

[37]Bruce M. Taylor, "The Effects of Certain Fitness Programs Upon the Cardio-Vascular and Muscular Status of Business Men," (unpublished Master's thesis, University of British Columbia, Vancouver, 1961), pp. 26-131.

divided into groups using: (1) three circuits using one-half maximum dosage, (2) three circuits using three-fourths maximum dosage, (3) three circuits using two-thirds maximum dosage, and (4) three circuits using no prescribed dosage. Tests used to determine physical condition were the Washington State University Physical Fitness Test, Rodgers Physical Fitness Index, and the Harvard Step Test. Results of the Washington Test indicated that the three training methods using a prescribed dosage produced results which were significantly better at the .05 level than the training program without a prescribed dosage. The other tests given indicated no significant difference between the groups.[38]

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[38] Malvin G. Undlin, "A Comparison of Four Methods of Circuit Training" (unpublished Master's thesis, Washington State University, Pullman, 1965), pp. 14-32.

CHAPTER III

PROCEDURE FOR OBTAINING DATA

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PROCEDURE FOR OBTAINING DATA

The procedures for collecting the data to compare the modified DeLorme-Watkins, traditional strength, and circuit training methods of progressive resistance exercises are described in this chapter.

I. SOURCE OF DATA

Thirty-three members of the freshman and varsity football squad at South Dakota State University who were not engaged in a winter sport were selected as subjects for this study. Three subjects, however, were dropped from the study due to health reasons so that the final sample consisted of thirty freshman and varsity football players. The physical characteristics of the subjects appear in Table I.

II. ORGANIZATION OF THE STUDY

A meeting was held with the subjects on December 18, 1968, to orient and to inform the subjects as to their group assignment into one of the three training programs. Assignment into the three non-equated groups was randomly completed by the "track pill box" method. An instruction sheet for each training program was presented to the members of each group. The training program covered a period of seven weeks (from February 5 to March 26) with the subjects meeting on

TABLE I

PHYSICAL CHARACTERISTICS OF SUBJECTS

Group	Initials	Height	Weight
A	R.V.	5'11"	175
A	T.H.	5'8"	198
A	A.A.	6'2"	186
A	J.H.	6'0"	245
A	V.H.	5'10"	190
A	R.V.	6'1"	212
A	C.T.	6'3"	230
A	B.E.	5'10"	165
A	S.T.	6'2"	225
A	T.R.	6'3"	210
A	C.S.	6'2"	200
B	B.K.	6'0"	204
B	G.R.	6'2"	215
B	T.E.	6'2"	195
B	T.K.	5'11"	182
B	C.R.	6'1"	216
B	T.J.	6'4"	220
B	D.A.	6'4"	205
B	B.A.	6'1"	198
B	R.R.	5'11"	175
C	D.J.	5'11"	204
C	M.F.	6'1"	195
C	B.H.	6'0"	210
C	R.D.	6'1"	185
C	M.R.	6'3"	210
C	T.R.	6'2"	240
C	T.B.	6'2"	180
C	D.J.	6'4"	250
C	T.S.	5'11"	175
C	J.V.	5'11"	185

Group A - DeLorme-Watkins training method
Group B - traditional strength training method
Group C - circuit training method

Monday, Wednesday, and Friday for twenty-one training sessions. Tests for muscular strength, muscular endurance, and muscular girth were administered before the program began, Test I (January 6-16); at the end of three weeks of training, Test II (February 26); and at the end of the program, Test III (March 27-April 2). Two weeks separated Test I and the actual start of the program because of semester break. Tests for cardiovascular endurance were administered only at Test I and Test III.

III. THE CONDITIONING PROGRAM

The three types of conditioning programs all consisted of the following ten exercises: bench press, military press, two arm curl, erect rowing, lat exercises, sit-up, bent rowing, leg press, heel raisers, and dead lift. All exercises except the bent rowing and dead lift were performed on the Universal Gym. Pilot studies were conducted prior to the beginning of the study to determine program and testing methods and to thoroughly acquaint the investigator with all facets of the training and testing procedures.

Modified DeLorme-Watkins method. The maximum weight that the subjects could lift through six repetitions was established by trial and error at the beginning of the modified DeLorme-Watkins training program. The program consisted of three sets, with one-half the maximum weight for six repetitions used on the first set, three-fourths the maximum weight on the second set, and the maximum weight on the

last set. When eight repetitions were reached for an exercise, the weight for that exercise was increased by ten pounds.

Traditional strength method. The traditional strength training method employed the same procedure as the modified DeLorme-Watkins method to establish the maximum weight through six repetitions. The training differed, however, from the modified DeLorme-Watkins method in that this weight was used for all three sets of each exercise. When eight repetitions were reached on the first set of one of the exercises, the weight for that exercise was increased by ten pounds.

Circuit training method. The weight used at each station for circuit training was predetermined by a pilot study using subjects of similar physical traits to those who were used in the study. The weights initially used were:

1. Bench Press - 100 pounds
2. Sit-Up - No weight. The exercise was performed on an inclined board.
3. Leg Press - 220 pounds
4. Lat Exercise - 90 pounds
5. Erect Row - 60 pounds
6. Heel Raisers - 250 pounds
7. Military Press - 90 pounds
8. Bent Rowing - 75 pounds
9. Dead Lift - 180 pounds
10. Curls - 50 pounds

All of the items in the circuit were heavy resistance exercises to allow a fair comparison with the other two methods of training. All weights were increased by ten pounds after the testing period on February 26.

The training dose for the circuit was determined for each subject by having the subject perform as many repetitions as possible in thirty seconds at each station with a one-minute rest between stations. Many individuals used the maximum number of repetitions in one minute to determine the training dose; however, since all of the items in the circuit were heavy resistance exercises, the test was for maximum repetitions in thirty seconds. If the subject reached his maximum number of repetitions before the end of the thirty-second period, that number of repetitions was used. The number of repetitions performed at each station was reduced by one-half to establish the training dose.

IV. COLLECTION OF THE DATA

Data were collected for all subjects on three occasions. The subjects were tested on muscular strength, muscular endurance, muscular girth, and cardiovascular endurance.

Muscular strength measurement. Muscular strength was measured by the maximum weight which could be lifted through one complete range of motion in a single muscular contraction. Muscular strength was measured only on the bench press and military press and was measured

and recorded to the nearest ten pounds.[39]

Muscular endurance measurement. Muscular endurance was measured by the performance of as many repetitions as possible using a weight which was equal to two-thirds of the weight established on the muscular strength test. The distance that each subject moved the weight was recorded, and endurance was recorded in units of work measured in foot-pounds which was calculated by weight times repetitions times distance the weight was moved and was measured and recorded to the nearest foot-pound.

Muscular girth measurement. Muscular girth was measured with the subjects standing erect, arm held out to the side of the body at the shoulder level, elbow straight, palm facing up, and the muscles relaxed. The tape was placed around the largest part of the upper arm for the measurement and was measured and recorded to the nearest one-eighth inch.[40]

Cardiovascular endurance measurement. Cardiovascular endurance was measured by the use of a bicycle ergometer test. The subjects pedalled at a rate of sixty revolutions per minute guided by the beat of a metronome. The subjects were allowed to warm up on the bicycle

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[39] Thomas L. DeLorme and Arthur L. Watkins, Progressive Resistance Exercise (New York: Appleton-Century-Crofts, Inc., 1951), p. 127.

[40] Jack R. Leighton, Progressive Weight Training (New York: The Ronald Press Company, 1961), p. 68.

without resistance until they were able to pedal rhythmically at sixty revolutions per minute. The resistance was zero kilograms for the first minute of the test and was increased by one-half kilogram each minute thereafter until the subject was forced to stop or unable to maintain the sixty revolutions per minute due to fatigue.

Heart rate was recorded by the use of a physiograph-six which was manufactured by the E. and M. Instrument Company. Three electrodes were placed on the subject with two on the chest in the area below the pectoralis muscles and one on the back. The heart rate for the last twenty seconds of the last minute that the subject could complete on the bicycle ergometer was multiplied by three to determine the maximum heart rate. Maximal work per heart rate (maximal w/hr) was the measure used to record cardiovascular endurance. Work was calculated by multiplying the distance travelled in one minute (360 meters) times the resistance in kilograms for that minute and was recorded in units of kilogram meters (kgm). Maximal work was then divided by the maximal heart rate recorded as kgm/hr.[41]

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[41]H. Roskamm, "Optimum Patterns of Exercise for Healthy Adults," The Canadian Medical Association Journal, 96:895-899, March, 1967.

CHAPTER IV

ANALYSIS AND DISCUSSION OF RESULTS

CHAPTER IV

ANALYSIS AND DISCUSSION OF RESULTS

The subjects were randomly divided into a modified DeLorme-Watkins training group (N=11), a traditional strength-training group (N=9), and a circuit training group (N=10). The subjects were tested for muscular strength, muscular endurance, muscular girth, and cardiovascular endurance.

I. ORGANIZATION OF THE DATA FOR TREATMENT

The data were organized in a manner that permitted an analysis of the changes that occurred in the variables between successive tests. The "difference method" was used to determine the *t* ratio of the mean changes within each group from Test I and Test II, Test II and Test III, and Test I and Test III.[42] The difference between the effects of the treatments was determined by using Duncan's Multiple-Range Test as described by Bruning and Kintz.[43] The .05 level of confidence was the minimum level needed in order for a difference to be considered significant.

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[42] Henry E. Garrett, Statistics in Psychology and Education (New York: David McKay Company, Inc., 1966), p. 227.

[43] James L. Bruning and B. L. Kintz, Computational Handbook of Statistics (Glenview: Scott, Foresman, and Company, 1968), pp. 115-117.

The raw data, mean, and standard deviations of the various measurements in Test I, Test II, and Test III are shown in Appendix A, B, and C, respectively.

II. ANALYSIS OF THE DATA

Analysis of results within groups

The changes in the selected variables between Test I and Test II, Test II and Test III, and Test I and Test III are shown in Tables II, III, and IV. The *t* ratios needed to denote significance at the .05 and .01 levels of confidence, respectively, are listed as follows for their respective degrees of freedom: eight degrees of freedom, 2.31 and 3.36; nine degrees of freedom, 2.26 and 3.25; ten degrees of freedom, 2.23 and 3.17.[44]

Changes within groups from Test I to Test II. The changes from Test I to Test II for the three training groups in bench press strength, military press strength, bench press endurance, military press endurance, and muscle girth are shown in Table II. There was an overall increase in bench press strength for the three groups between Test I and Test II. The traditional strength and circuit training methods increased bench press strength beyond the .01 and .05 levels of confidence, respectively, as indicated by *t* ratios of 4.00 and 3.12.

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[44] Henry E. Garrett, Elementary Statistics (second edition; New York: David McKay Company, Inc., 1962), p. 182.

However, the modified DeLorme-Watkins method did not show a significant increase.

All three training methods increased strength in the military press; however, the mean gains were not significant.

The circuit training group increased their bench press endurance beyond the .01 level of confidence as indicated by a *t* ratio of 3.85. Bench press endurance for the modified DeLorme-Watkins training method increased 574 foot-pounds which was significant beyond the .05 level of confidence, while the traditional strength training group experienced no significant change.

Neither the modified DeLorme-Watkins nor the traditional strength training methods significantly increased military press endurance. The mean increase for the circuit training group rendered a *t* value of 3.87 which was significant beyond the .01 level of confidence.

The traditional strength training group produced a significant gain beyond the .01 level of confidence in muscle girth between Test I and Test II as indicated by a *t* ratio of 3.37. Neither of the other two training groups showed a significant change.

Test II was not given for cardiovascular endurance; thus, this variable is discussed only in the comparison of the changes from Test I to Test III (see Table IV).

TABLE II

CHANGES WITHIN GROUPS FROM
TEST I TO TEST II

[a]Group	Variable	Test I mean	Test II mean	$\bar{d}$	$SE_{\bar{d}}$	t
A	Bench	177	189	12	5.39	2.22
B	press	209	229	20	5.00	4.00*
C	strength (lbs.)	179	191	12	3.84	3.12**
A	Military	162	164	2	3.84	.52
B	press	174	180	6	3.11	1.92
C	strength (lbs.)	160	164	4	4.10	.97
A	Bench	3562	4136	574	203	2.82**
B	press	4441	4229	-212	277	.76
C	endurance (ft.-lbs.)	3455	4447	992	257	3.85*
A	Military	2770	3059	289	211	1.36
B	press	2555	2981	426	260	2.20
C	endurance (ft.-lbs.)	2864	3491	627	162	3.87*
A	Muscle	13.06	13.10	0.04	0.11	.36
B	girth	13.45	13.72	0.27	0.08	3.37*
C	(in.)	13.16	13.28	0.12	0.14	.85

[a]Group A - modified DeLorme-Watkins
Group B - traditional strength
Group C - circuit training

* denotes significance at the .01 level of confidence
**denotes significance at the .05 level of confidence

Changes within groups from Test II to Test III. Table III indicates the changes from Test II to Test III within each group for strength, muscular endurance, and girth. All of the training methods showed an increase in bench press strength from Test II to Test III. The modified DeLorme-Watkins and circuit training groups increased strength at the .01 level of confidence as indicated by *t* scores of 3.26 and 3.32, respectively. The *t* ratio of 2.86 for the traditional strength training group was significant beyond the .05 level of confidence.

The modified DeLorme-Watkins training group showed a significant gain in military press strength beyond the .01 level of confidence with a *t* ratio of 5.75. Although there was a gain in military press strength for the traditional strength and circuit training groups from Test II to Test III, the gains were not significant.

None of the three training methods produced a significant gain in bench press endurance between Test II and Test III. In military press endurance, however, both the circuit training and the traditional strength training groups significantly improved at the .05 level of confidence with *t* values of 2.79 and 2.55, respectively. The modified DeLorme-Watkins training group did not significantly change from Test II to Test III.

The muscular girth measurement indicated that the modified DeLorme-Watkins method of training increased girth beyond the .01 level of confidence with a *t* score of 6.40. The traditional strength

TABLE III

CHANGES WITHIN GROUPS FROM
TEST II TO TEST III

[a] Group	Variable	Test II mean	Test III mean	$\bar{d}$	$SE_{\bar{d}}$	$t_{\bar{d}}$
A	Bench	189	206	17	5.20	3.26*
B	press	229	241	12	4.19	2.86**
C	strength (lbs.)	191	208	17	5.12	3.32*
A	Military	164	177	13	2.26	5.75*
B	press	180	191	11	5.12	2.15
C	strength (lbs.)	164	168	4	2.11	1.90
A	Bench	4136	4212	76	325	0.23
B	press	4229	4471	242	436	0.56
C	endurance (ft.-lbs.)	4447	4157	-290	262	1.11
A	Military	3059	3471	412	187	2.20
B	press	2981	3643	662	260	2.55**
C	endurance (ft.-lbs.)	3491	3960	469	168	2.79**
A	Muscle	13.10	13.42	0.32	0.05	6.40*
B	girth	13.72	14.02	0.30	0.12	2.50**
C	(in.)	13.28	13.40	0.12	0.12	1.00

[a]
Group A - modified DeLorme-Watkins
Group B - traditional strength
Group C - circuit training

* denotes significance at the .01 level of confidence
**denotes significance at the .05 level of confidence

training group increased girth beyond the .05 level of confidence with a *t* score of 2.50. The circuit training group did not significantly change in muscle girth.

Changes within groups from Test I to Test III. The changes from Test I to Test III for the three training groups in each of the six variables are shown in Table IV. All three training methods showed gains in bench press strength beyond the .01 level of confidence as indicated by *t* ratios of 5.49, 5.12, and 7.65, respectively. In military press strength, the modified DeLorme-Watkins and traditional strength training groups significantly improved at the .01 and .05 levels of confidence, respectively. The circuit training group did not produce a significant gain in military press strength from Test I to Test III.

In the bench press endurance measurement all training methods increased; however, none of the three groups showed a significant gain in endurance. In the military press endurance measure, the modified DeLorme-Watkins and circuit training groups showed gains which were significant beyond the .05 and .01 levels of confidence, respectively. The *t* ratios for the two training groups were 2.42 and 7.88. The traditional strength training group did not significantly change in the military press endurance measure.

Two of the three groups experienced gains significant beyond the .01 level of confidence in muscle girth with *t* scores of 3.60 for the modified DeLorme-Watkins training group and 4.38 for the traditional

TABLE IV

CHANGES WITHIN GROUPS FROM
TEST I TO TEST III

[a]Group	Variable	Test I mean	Test III mean	$\bar{d}$	$SE_{\bar{d}}$	t
A	Bench	177	206	29	5.28	5.49*
B	press	209	241	32	6.25	5.12*
C	strength (lbs.)	179	208	29	3.79	7.65*
A	Military	162	177	15	3.13	4.79*
B	press	174	191	17	7.21	2.35**
C	strength (lbs.)	160	168	8	4.52	1.77
A	Bench	3562	4212	650	453	1.45
B	press	4441	4471	30	834	.04
C	endurance (ft.-lbs.)	3455	4157	702	459	1.53
A	Military	2770	3471	701	289	2.42**
B	press	2555	3643	1088	894	1.22
C	endurance (ft.-lbs.)	2864	3960	1096	141	7.88*
A	Muscle	13.06	13.42	0.36	0.10	3.60*
B	girth	13.45	14.02	0.57	0.13	4.38*
C	(in.)	13.16	13.40	0.24	0.12	2.00
A	Cardio-	9.70	10.57	0.87	0.13	6.69*
B	vascular	10.11	10.65	0.54	0.19	7.71*
C	endurance (kgm/hr)	10.43	11.72	1.29	0.11	11.73*

[a]Group A - modified DeLorme-Watkins
Group B - traditional strength
Group C - circuit training

* denotes significance at the .01 level of confidence
**denotes significance at the .05 level of confidence

strength training group. The circuit training group did not significantly change.

All three groups significantly improved their cardiovascular endurance beyond the .01 level of confidence. The greatest improvement was made by the circuit training group.

Analysis of results among groups.

A comparison of the effects of the three treatments on the six variables are shown in Tables V, VI, and VII. The critical value for twenty-seven degrees of freedom and a K value of two is 2.903 at the .05 level of confidence and 3.916 at the .01 level of confidence. The critical value for a K value of three is 3.050 at the .05 level of confidence and 4.200 at the .01 level of confidence for twenty-seven degrees of freedom.[45]

Changes among groups from Test I to Test II. The means of the changes and the required R_2 and R_3 values needed for significance at the .05 level of confidence for the changes between Test I and Test II are found in Table V. There was no significant difference among the three groups in either bench press strength or military press strength. The gains in bench press endurance for the modified DeLorme-Watkins and circuit training groups were both significantly greater than the gains

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[45] Bruning and Kintz, op. cit., pp. 237-241.

TABLE V

CHANGES AMONG GROUPS FROM TEST I TO TEST II

Variable	Group mean change compared[a]	$\bar{d}$	R_2	R_3
Bench press strength (lbs.)	Group A (12) vs. Group B (20)	8	13	14
	Group B (20) vs. Group C (12)	8	13	14
	Group A (12) vs. Group C (12)	0	13	14
Military press strength (lbs.)	Group A (2) vs. Group B (6)	4	11	11
	Group B (6) vs. Group C (4)	2	11	11
	Group A (2) vs. Group C (4)	2	11	11
Bench press endurance (ft.-lbs.)	Group A (574) vs. Group B (-212)	786**	708	744
	Group B (-212) vs. Group C (992)	1204*	708	744
	Group A (574) vs. Group C (992)	418	708	744
Military press endurance (ft.-lbs.)	Group A (289) vs. Group B (426)	137	615	646
	Group B (426) vs. Group C (627)	201	615	646
	Group A (289) vs. Group C (627)	338	615	646
Muscle girth (in.)	Group A (.04) vs. Group B (.27)	.23	.32	.33
	Group B (.27) vs. Group C (.12)	.15	.32	.33
	Group A (.04) vs. Group C (.12)	.08	.32	.33

[a]Group A - modified DeLorme-Watkins
Group B - traditional strength
Group C - circuit training

* denotes significance at the .01 level of confidence
**denotes significance at the .05 level of confidence

for the traditional strength training group beyond the .05 and .01 levels of confidence, respectively. However, there was not a significant difference between the gains for the modified DeLorme-Watkins and circuit training groups. Finally, there was no significant difference among the groups in their military press endurance changes and the muscle girth changes from Test I to Test II.

Changes among groups from Test II to Test III. The mean changes and the difference among the mean changes from Test II to Test III are shown in Table VI. The modified DeLorme-Watkins and traditional strength training groups increased all measurements of strength, muscular endurance, and muscle girth. The circuit training group increased in strength and endurance on the military press and muscle girth measurements; however, a decrease of 290 foot-pounds was experienced for bench press endurance. The differences in changes, however, among the three training groups were not significant for any of the variables studied.

Changes among groups from Test I to Test III. The mean changes and the differences among the mean changes from Test I to Test III are shown in Table VII. Both the modified DeLorme-Watkins and circuit training groups improved to a significantly greater extent than the traditional strength training group in muscular endurance as measured by the bench press. The modified DeLorme-Watkins and circuit training groups were also significantly better than the traditional strength

TABLE VI

CHANGES AMONG GROUPS FROM
TEST II TO TEST III

Variable	Group mean change compared[a]	$\bar{d}$	R_2	R_3
Bench press strength (lbs.)	Group A (17) vs. Group B (12)	5	15	16
	Group B (12) vs. Group C (17)	5	15	16
	Group A (17) vs. Group C (17)	0	15	16
Military press strength (lbs.)	Group A (13) vs. Group B (11)	2	10	11
	Group B (11) vs. Group C (4)	7	10	11
	Group A (13) vs. Group C (4)	9	10	11
Bench press endurance (ft.-lbs.)	Group A (76) vs. Group B (242)	166	1071	1125
	Group B (242) vs. Group C (-290)	532	1071	1125
	Group A (76) vs. Group C (-290)	366	1071	1125
Military press endurance (ft.-lbs.)	Group A (412) vs. Group B (662)	250	514	541
	Group B (662) vs. Group C (469)	193	514	541
	Group A (412) vs. Group C (469)	57	514	541
Muscle girth (in.)	Group A (.32) vs. Group B (.30)	.02	.27	.29
	Group B (.30) vs. Group C (.12)	.18	.27	.29
	Group A (.32) vs. Group C (.12)	.20	.27	.29

[a] Group A - modified DeLorme-Watkins
Group B - traditional strength
Group C - circuit training

TABLE VII

CHANGES AMONG GROUPS FROM
TEST I TO TEST III

Variable	Group mean change compared[a]	$\bar{d}$	R_2	R_3
Bench press strength (lbs.)	Group A (29) vs. Group B (32)	3	14	14
	Group B (32) vs. Group C (29)	3	14	14
	Group A (29) vs. Group C (29)	0	14	14
Military press strength (lbs.)	Group A (15) vs. Group B (17)	2	21	22
	Group B (17) vs. Group C (8)	9	21	22
	Group A (15) vs. Group C (8)	7	21	22
Bench press endurance (ft.-lbs.)	Group A (650) vs. Group B (30)	620*	337	354
	Group B (30) vs. Group C (702)	672*	337	354
	Group A (650) vs. Group C (702)	52	337	354
Military press endurance (ft.-lbs.)	Group A (701) vs. Group B (1088)	387	737	775
	Group B (1088) vs. Group C (1096)	8	737	775
	Group A (701) vs. Group C (1096)	395	737	775
Muscle girth (in.)	Group A (.36) vs. Group B (.57)	.21	.34	.36
	Group B (.57) vs. Group C (.24)	.33	.34	.36
	Group A (.36) vs. Group C (.24)	.12	.34	.36
Cardio-vascular endurance (kgm/hr)	Group A (.87) vs. Group B (.54)	.33*	.17	.18
	Group B (.54) vs. Group C (1.29)	.75*	.17	.18
	Group A (.87) vs. Group C (1.29)	.42*	.17	.18

[a]
Group A - modified DeLorme-Watkins
Group B - traditional strength
Group C - circuit training

*denotes significance at the .01 level of confidence

training group in their cardiovascular endurance gains. The circuit training group experienced significantly greater gains in cardiovascular endurance than the modified DeLorme-Watkins training group. There were no other significant differences among the groups from Test I to Test III.

III. DISCUSSION OF RESULTS

The modified DeLorme-Watkins and traditional strength training groups significantly improved both bench press and military press strength as well as muscle girth. The circuit training group significantly improved only in bench press strength. The greater gains made by the modified DeLorme-Watkins and traditional strength training groups support literature indicating that strength and hypertrophy are best developed by heavy loads and few repetitions.[46,47,48,49]

The circuit training group made overall gains in endurance which

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[46] Samuel Homola, Muscle Training for Athletes (West Nyack: Parker Publishing Company, Inc., 1968), p. 17.

[47] Frank D. Sills, Laurence E. Morehouse, and Thomas L. DeLorme, Weight Training in Sports and Physical Education (Washington: American Association for Health, Physical Education, and Recreation, 1962), p. 18.

[48] R. E. McGovern and H. B. Liscomb, "Useful Modifications of Progressive Resistance Exercise Technique," Archives of Physical Medicine and Rehabilitation, 34:475-477, August, 1953.

[49] Richard A. Berger, "Optimum Repetitions for the Development of Strength," The Research Quarterly, 33:334-338, October, 1962.

were superior to the modified DeLorme-Watkins and traditional strength training groups from Test I to Test II, and Test I to Test III. Training methods employing lighter weights and a larger number of repetitions are generally accepted as the best methods for the development of muscular endurance.[50,51,52]

The circuit training group did not make significant gains in muscular endurance from Test II to Test III. The investigator observed that the circuit training group made rapid gains in endurance from Test I to Test II, and then levelled off from Test II to Test III; however, the overall gain in muscular endurance from Test I to Test III was substantial for both the bench press and military press.

Massey, et. al., state that exercises must be carried out continuously over a period of time to develop cardiovascular endurance.[53] The circuit training group used strenuous exercises continuously for approximately ten minutes and experienced significant gains in cardiovascular endurance. The gains in cardiovascular endurance by the

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[50] Robert Simmons, "The Effect of Circuit Training Upon Cardiovascular Condition and Motor Performance on the Modified Harvard Step Test," The Research Quarterly, 34:154-157, May, 1963.

[51] Donna Jean Graham Maroc, "The Effect of Two Programs of Circuit Training on the Physical Fitness of College Women," (unpublished Master's thesis, The University of Washington, Seattle, 1965), pp. 54-117.

[52] McGovern and Liscomb, op. cit., pp. 475-477.

[53] Benjamin H. Massey, et. al., The Kinesiology of Weight Lifting (Dubuque: Wm. C. Brown Company, 1959), p. 58.

circuit training group were also significantly greater than those made by the modified DeLorme-Watkins and traditional strength training groups. Both the modified DeLorme-Watkins and traditional strength training groups, however, also significantly improved cardiovascular endurance.

On the basis of the findings of this study, the writer concluded that any progressive resistance exercise program employing the overload principle may be used as an effective method for improving physical condition. Methods of training employing heavy weights and few repetitions such as the modified DeLorme-Watkins and traditional strength training methods tend to develop greater gains in muscular strength and girth. Circuit training tends to develop general (cardiovascular) endurance and local (muscular) endurance more than the modified DeLorme-Watkins and traditional strength training methods.

The null hypothesis stated that there would be no significant difference among the three methods of weight training relative to the development of muscular strength, muscular endurance, muscle girth, and cardiovascular endurance. The null hypothesis was retained for bench press strength, military press strength, military press endurance, and muscle girth for the changes from Test I to Test II. However, the null hypothesis was rejected for bench press endurance, since the circuit training and modified DeLorme-Watkins training groups made gains which were significantly greater than the gains made by the traditional strength training group.

The null hypothesis was retained for all measurements for the changes from Test II and Test III and for the changes from Test I to Test III for bench press strength, military press strength, military press endurance, and muscle girth. Gains in bench press endurance by the modified DeLorme-Watkins and circuit training groups were significantly greater than for the traditional strength training group and led to the rejection of the null hypothesis. The null hypothesis was also rejected for cardiovascular endurance, since the modified DeLorme-Watkins training group made improvements in cardiovascular endurance which were significantly greater than the traditional strength training group. The gains made by the circuit training group were significantly greater than the gains made by either the modified DeLorme-Watkins or traditional strength training groups.

CHAPTER V

SUMMARY, CONCLUSION, AND RECOMMENDATIONS

CHAPTER V

SUMMARY, CONCLUSION, AND RECOMMENDATIONS

I. SUMMARY

The purpose of this investigation was to compare the effects of three different weight training programs on the development of muscular strength, muscular endurance, muscular girth, and cardiovascular endurance. Thirty freshman and varsity football players from the 1968 South Dakota State University football teams were used as subjects. The subjects were randomly divided into three different groups. One group trained using a modification of the DeLorme-Watkins method of training; the second group followed the traditional strength training method, while the third followed a circuit training program.

Training covered a period of seven weeks, with the subjects meeting on Monday, Wednesday, and Friday for twenty-one training sessions. Tests for muscular strength, endurance, and girth were administered before the program began, at the end of three weeks of training, and at the conclusion of the training program. Cardiovascular endurance was determined and data were recorded at the beginning and at the end of the training program. Two weeks separated the initial test and the start of the program because of the semester break.

The conditioning programs for the three groups consisted of ten exercises: bench press, military press, two arm curl, erect rowing, lat exercise, sit-up, bent rowing, leg press, heel raisers, and dead lift.

The test described by DeLorme was used to measure muscular strength.[54] The test consisted of the one RM measurement on the bench press and the military press and was measured in pounds.

Muscular endurance was measured by a modification of the test described by DeLorme.[55] The subjects performed as many repetitions as possible using a weight which was equal to two-thirds of the weight established by the one RM. The weight, distance the weight was moved, and repetitions were recorded. The endurance measurement was recorded in units of work measured in foot-pounds which was calculated by multiplying the weight times repetitions times distance.

The test described by Leighton was used to measure muscular girth.[56] The girth of the upper right arm was measured with the subject standing erect, arm held out to the side of the body at the shoulder level, elbow straight, palm facing up, and the muscle relaxed.

Cardiovascular endurance was measured employing the technique described by Roskamm.[57] The test consisted of the maximum work per heart rate that the subjects could perform on a bicycle ergometer and

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[54] Sills, Morehouse, and DeLorme, op. cit., p. 99.

[55] Ibid.

[56] Jack R. Leighton, Progressive Weight Training (New York: The Ronald Press Company, 1961), p. 68.

[57] H. Roskamm, "Optimum Patterns of Exercise for Healthy Adults," The Canadian Medical Association Journal, 96:895-899, March, 1967.

was recorded in kgm/hr. Heart rate was recorded by the use of a physiograph-six manufactured by the E. and M. Instrument Company.

In order to determine whether there were significant changes within the groups between Test I and Test II, Test II and Test III, and Test I and Test III, a *t* ratio was calculated for each variable by the "difference method" as described by Garrett.[58]

The traditional strength and circuit training groups showed a significant increase in bench press strength from Test I to Test II. Significant increases were experienced for bench press endurance by the modified DeLorme-Watkins and circuit training groups, while only the circuit training group significantly increased military press endurance. The traditional strength training group experienced the only significant increase in muscle girth.

All of the training methods produced increases in bench press strength from Test II to Test III. The modified DeLorme-Watkins and circuit training groups showed significant gains in military press strength beyond the .01 level of confidence. The gain for the traditional strength training group was significant beyond the .05 levels of confidence. None of the three training methods produced a significant gain in bench press endurance. However, in the military press endurance measurement both the traditional strength and circuit training groups improved beyond the .05 level of confidence. The modified

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[58]Henry E. Garrett, Statistics in Psychology and Education (New York: David McKay Company, Inc., 1966), p. 227.

DeLorme-Watkins and traditional strength methods of training produced gains in muscle girth beyond the .01 and .05 levels of confidence, respectively.

All three training methods improved bench press strength beyond the .01 level of confidence from Test I to Test III. Improvements beyond the .01 and .05 levels of confidence were made in military press strength by the modified DeLorme-Watkins and traditional strength training methods, respectively. None of the three groups improved bench press endurance; however, the modified DeLorme-Watkins and circuit training groups showed gains in military press endurance which were significant beyond the .05 and .01 levels of confidence, respectively. The modified DeLorme-Watkins and traditional strength training groups improved the muscle girth measurement beyond the .01 level of confidence. All three groups significantly improved in their cardiovascular endurance beyond the .01 level of confidence. The greatest improvement was made by the circuit training group.

Duncan's Multiple-Range Test as described by Bruning and Kintz was used to determine if there were significant differences between the changes in the variables studied among the groups between Test I and Test II, Test II and Test III, and Test I and Test III.[59]

There was no significant difference among the three groups in the development of bench press strength or military press strength from

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[59]James L. Bruning and B. L. Kintz, Computational Handbook of Statistics (Glenview: Scott, Foresman, and Company, 1968), pp. 115-117.

Test I to Test II. The modified DeLorme-Watkins and circuit training methods were both significantly greater than the traditional strength training method in the development of bench press endurance; however, there was not a significant difference between the modified DeLorme-Watkins and circuit training groups. There was no significant difference among the groups in military press endurance and muscle girth.

The differences in changes among the three training groups were not significant from Test II to Test III.

Changes among groups from Test I to Test III indicated that both the modified DeLorme-Watkins and circuit training groups improved to a significantly greater extent than the traditional strength training group in muscular endurance for the bench press. The modified DeLorme-Watkins and circuit training groups were also significantly better than the traditional strength training group in their cardiovascular endurance gains. The circuit training group also experienced significantly greater gains in cardiovascular endurance than the modified DeLorme-Watkins training group. There were no other significant differences among the groups from Test I to Test III.

II. CONCLUSIONS

Within the limitations of this study, the following conclusions were made:

1. The three training programs used for this study all improved strength, muscular endurance, girth, and cardiovascular endurance.

2. The modified DeLorme-Watkins, traditional strength, and circuit training programs produced basically the same results for muscular strength, endurance and girth; however, the circuit training program produced the best results for cardiovascular endurance.
3. Since the three methods of weight training produced basically the same results, the investigator suggests the use of circuit training for the development of physical fitness due to the shorter period of time required to complete the daily training program.

III. RECOMMENDATIONS

The following recommendations are made for further study:

1. A similar study be conducted for retention with a test on strength, endurance, girth, and cardiovascular endurance given six weeks following the conclusion of the training program.
2. A similar study be conducted using only subjects who have had no previous experience in weight training.
3. A similar study be conducted in which a control group is employed.
4. A similar study be conducted in which the outside activities of the subjects be controlled.

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APPENDIXES

APPENDIX A

INDIVIDUAL SCORES FOR STRENGTH IN TESTS I, II, AND III FOR THE MODIFIED DELORME-WATKINS TRAINING GROUP

SUBJECTS	TEST I		TEST II		TEST III	
Initials	Bench Press (lbs.)	Military Press (lbs.)	Bench Press (lbs.)	Military Press (lbs.)	Bench Press (lbs.)	Military Press (lbs.)
R.V.	160	140	210	150	220	180
T.H.	180	150	190	160	230	170
A.A.	170	140	170	150	170	160
J.H.	170	170	170	170	210	180
V.H.	180	170	170	150	210	180
R.V.	200	190	210	190	200	190
C.T.	160	160	170	160	190	170
B.E.	170	160	180	160	190	170
S.T.	190	170	220	190	240	200
T.R.	210	170	210	160	220	180
C.S.	160	160	180	160	190	170
Mean	177	162	189	164	206	177
S.D.	22	12	19	8	20	14

APPENDIX A (continued)

INDIVIDUAL SCORES FOR STRENGTH IN TESTS I, II, AND III FOR THE TRADITIONAL STRENGTH TRAINING GROUP

SUBJECTS	TEST I		TEST II		TEST III	
Initials	Bench Press (lbs.)	Military Press (lbs.)	Bench Press (lbs.)	Military Press (lbs.)	Bench Press (lbs.)	Military Press (lbs.)
B.K.	250	190	260	190	260	180
G.R.	210	160	230	150	240	160
T.E.	270	170	310	190	310	210
T.K.	210	210	260	220	290	260
C.R.	200	170	210	170	240	190
T.J.	220	200	240	200	240	190
D.A.	180	160	190	180	200	180
B.A.	180	160	190	160	210	170
R.R.	160	150	170	160	180	180
Mean	209	174	229	180	241	191
S.D.	64	23	41	21	39	29

APPENDIX A (continued)

INDIVIDUAL SCORES FOR STRENGTH IN TESTS I, II, AND III FOR THE CIRCUIT TRAINING GROUP

SUBJECTS	TEST I		TEST II		TEST III	
Initials	Bench Press (lbs.)	Military Press (lbs.)	Bench Press (lbs.)	Military Press (lbs.)	Bench Press (lbs.)	Military Press (lbs.)
D.J.	180	160	190	190	220	160
M.F.	170	160	170	160	200	170
B.H.	160	160	160	160	190	160
R.D.	160	160	180	160	200	160
M.R.	170	140	190	150	200	160
T.R.	280	220	300	200	280	200
T.B.	150	130	160	150	170	150
D.J.	180	150	210	170	210	170
T.S.	170	170	180	180	210	190
J.V.	170	150	170	140	200	160
Mean	179	160	191	164	208	168
S.D.	35	23	39	16	27	15

APPENDIX B

INDIVIDUAL SCORES FOR MUSCULAR ENDURANCE IN TESTS I, II, AND III FOR THE MODIFIED DELORME-WATKINS TRAINING GROUP

SUBJECTS	TEST I		TEST II		TEST III	
Initials	Bench Press (ft.-lb.)	Military Press (ft.-lb.)	Bench Press (ft.-lb.)	Military Press (ft.-lb.)	Bench Press (ft.-lb.)	Military Press (ft.-lb.)
R.V.	3749	2986	4175	2844	3621	2955
T.H.	4499	2975	4874	3080	4646	3273
A.A.	3490	2340	5327	3600	6246	3960
J.H.	3674	2112	4225	3590	3507	4378
V.H.	3060	3123	3240	2839	3750	2605
R.V.	3286	1820	2654	2503	3492	2048
C.T.	2259	1925	3302	2310	3697	3850
B.E.	3727	2822	4066	3386	3511	3574
S.T.	5460	4435	5513	3744	3675	3744
T.R.	3591	2112	4309	2534	4104	2995
C.S.	2388	3825	3808	3221	6079	4630
Mean	3562	2770	4136	3059	4212	3471
S.D.	850	783	838	470	970	724

APPENDIX B (continued)

INDIVIDUAL SCORES FOR MUSCULAR ENDURANCE IN TESTS I, II, AND III FOR THE TRADITIONAL STRENGTH TRAINING GROUP

SUBJECTS	TEST I		TEST II		TEST III	
Initials	Bench Press (ft.-lb.)	Military Press (ft.-lb.)	Bench Press (ft.-lb.)	Military Press (ft.-lb.)	Bench Press (ft.-lb.)	Military Press (ft.-lb.)
B.K.	3403	2890	4451	3112	4451	3112
G.R.	5635	2587	6038	2744	6440	3234
T.E.	3607	2251	3156	2660	2806	2864
T.K.	4250	1260	3284	1575	2098	2805
C.R.	5210	2214	4910	4026	3474	3331
T.J.	4296	3667	3723	2821	3437	3667
D.A.	5460	2860	4095	4320	6005	5040
B.A.	5611	2818	4993	3221	6079	4429
R.R.	2499	2445	3408	2347	5453	4303
Mean	4441	2555	4229	2981	4471	3643
S.D.	1056	614	886	776	1564	734

APPENDIX B (continued)

INDIVIDUAL SCORES FOR MUSCULAR ENDURANCE IN TESTS I, II, AND III FOR THE CIRCUIT TRAINING GROUP

SUBJECTS	TEST I		TEST II		TEST III	
Initials	Bench Press (ft.-lb.)	Military Press (ft.-lb.)	Bench Press (ft.-lb.)	Military Press (ft.-lb.)	Bench Press (ft.-lb.)	Military Press (ft.-lb.)
D.J.	3792	2756	4313	2756	3318	3674
M.F.	3476	2695	6083	3850	7189	4043
B.H.	4041	2957	4776	4224	3474	4435
R.D.	3762	2534	4925	2534	3557	2957
M.R.	3544	3802	4421	4800	4887	4858
T.R.	4323	3000	4550	3120	4655	4420
T.B.	2052	2419	4138	3072	4703	3840
D.J.	4081	2982	4010	3983	3491	4686
T.S.	3476	3273	4171	3150	3760	3868
J.V.	2002	2223	3080	3420	2541	2822
Mean	3455	2864	4447	3491	4157	3960
S.D.	760	430	724	670	1227	649

APPENDIX C

INDIVIDUAL SCORES FOR MUSCULAR GIRTH IN TESTS I, II, AND III FOR CARDIOVASCULAR ENDURANCE IN TESTS I AND III FOR THE MODIFIED DELORME-WATKINS TRAINING GROUP

SUBJECTS	TEST I		TEST II	TEST III	
Initials	Muscle girth (in.)	Cardiovascular endurance (kgm/hr)	Muscle girth (in.)	Muscle girth (in.)	Cardiovascular endurance (kgm/hr)
R.V.	12.50	10.44	12.38	13.00	11.61
T.H.	13.50	8.31	13.00	13.25	8.44
A.A.	12.00	9.23	12.75	12.88	9.68
J.H.	13.25	10.17	13.25	13.50	10.17
V.H.	12.25	9.68	12.00	12.50	10.65
R.V.	13.88	10.82	13.88	14.13	12.20
C.T.	13.75	9.36	13.38	13.75	10.48
B.E.	11.50		11.75	12.00	
S.T.	14.63	10.82	14.63	15.13	12.79
T.R.	13.50	8.45	14.00	14.38	9.09
C.S.	12.88		13.13	13.13	
Mean	13.06	9.70	13.10	13.42	10.57
S.D.	.86	.55	.89	.88	1.33

APPENDIX C (continued)

INDIVIDUAL SCORES FOR MUSCULAR GIRTH IN TESTS I, II, AND III FOR CARDIOVASCULAR ENDURANCE IN TESTS I AND III FOR THE TRADITIONAL STRENGTH TRAINING GROUP

SUBJECTS	TEST I		TEST II	TEST III	
Initials	Muscle girth (in.)	Cardiovascular endurance (kgm/hr)	Muscle girth (in.)	Muscle girth (in.)	Cardiovascular endurance (kgm/hr)
B.K.	14.50	8.85	14.75	14.50	9.38
G.R.	13.38	10.73	14.00	14.13	12.00
T.E.	13.00	10.48	13.13	13.25	11.38
T.K.	12.50	11.08	13.00	13.38	11.08
C.R.	14.00	10.29	14.25	14.38	10.59
T.J.	14.75	11.00	14.63	14.88	11.69
D.A.	13.13	8.33	13.50	14.13	8.92
B.A.	13.50		13.50	14.50	
R.R.	12.25	10.15	12.75	13.00	10 15
Mean	13.45	10.11	13.72	14.02	10.65
S.D.	.72	.98	.74	.45	1.02

APPENDIX C (continued)

INDIVIDUAL SCORES FOR MUSCULAR GIRTH IN TESTS I, II, AND III FOR CARDIOVASCULAR ENDURANCE IN TESTS I AND III FOR THE CIRCUIT TRAINING GROUP

SUBJECTS	TEST I		TEST II	TEST III	
Initials	Muscle girth (in.)	Cardiovascular endurance (kgm/hr)	Muscle girth (in.)	Muscle girth (in.)	Cardiovascular endurance (kgm/hr)
D.J.	14.50	11.00	14.63	14.25	12.79
M.F.	12.25	9.71	12.75	12.88	10.65
B.H.	12.50	10.91	12.88	13.13	12.19
R.D.	11.75	11.58	12.38	12.38	12.20
M.R.	13.75	11.38	14.13	14.38	13.45
T.R.	14.13	11.43	14.25	14.13	12.58
T.B.	12.00	8.44	12.13	12.25	9.38
D.J.	15.50	9.68	15.00	14.38	11.80
T.S.	12.50		12.13	13.00	
J.V.	12.75	9.71	12.50	13.00	10.48
Mean	13.16	10.43	13.28	13.40	11.72
S.D.	1.20	.98	1.02	.83	1.26