STRENGTH AND SELF-CONCEPT EFFECTS OF WEIGHT TRAINING

THE COMPARATIVE EFFECTS OF INTERVAL CIRCUIT AND HIGH INTENSITY WEIGHT TRAINING SYSTEMS ON STRENGTH AND SELF-CONCEPT OF HIGH SCHOOL BOYS

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SUMMARY

Crouse, Kevin Ernest. "The Comparative Effects of Interval Circuit and High Intensity Weight Training Systems on Muscular Strength, Cardiovascular Endurance, Girth Measures and Self-Concept of High School Boys."

<u>Statement of the Problem</u>

This study was designed to compare the effects of two weight training systems, the Interval Circuit and High Intensity systems on muscular strength, cardio-respiratory endurance, girth measures and self-concept of high school boys.

<u>Procedures</u>

Seventy Year One boys enrolled in four physical education classes at Highland Secondary School during the 1978-79 school year composed the original sample. Subjects were pretested for strength on six 1RM tests on the Universal Spartacus Apparatus. Cardio-respiratory endurance was estimated by Cooper's Twelve Minute Run. Flexed girth measurements of the chest, thigh and arm were recorded and self-concept was measured using the Tennessee Self-Concept Scale.

The High Intensity system of weight training utilized the same exercises and sequences as the Interval Circuit, but fewer sets were performed and at a slower rate emphasizing both the concentric and eccentric phase, stretching of

the muscle group and forced repetitions of the point of failure.

Groups trained every second school day on the Universal Spartacus apparatus for nine weeks and were then retested. A series of t tests were used to determine the difference both within and between groups. Level of significance for t values was set at the .05 level.

Conclusions

Within the limitations of the sample and procedures employed, the following conclusions seem justified.

1. The High Intensity method of strength training is equal to the Interval Circuit method in producing consistent increases in strength.

2. The Interval Circuit system of weight training will produce significant gains in self-concept.

3. Since the High Intensity system of training can be completed in two-thirds of the time required to complete the Interval Circuit program, the High Intensity program could be a valuable training technique for the Physical Educator when limited time is a factor.

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LIST OF TABLES

		Page
TABLE 1	Comparison of Pre Test and Post Test Strength Scores Within the Interval Circuit and Within the High Intensity Groups. Study One	52
TABLE 2	Comparison of Pretest and Post Test Mean Leg Strength Scores Within the High Intensity and Within the Interval Circuit Groups. Study Two	53
TABLE 3	Comparison of Pre Test and Post Test Mean 12 Minute Run Scores Within the Interval Circuit and Within the High Intensity Groups. Study Two	55
TABLE 4	Comparison of Pre Test and Post Test Mean Composite Girth Measurements Within the Interval Circuit and Within the High Intensity Groups. Study One	56
TABLE 5	Comparison of Pre Test and Post Test Mean Tennessee Self-Concept Scores Within the Interval Circuit and Within the High Intensity Groups. Study One	57
TABLE 6	Comparison of Mean Pre Test and Post Test Leg Strength Scores Between Groups. Study Two	60
TABLE 7	Comparison of Mean Pre Test and Post Test 12 Minute Run Scores Between Groups. Study One	61
TABLE 8	Comparison of Mean Pre Test and Post Test Composite Girth Measurements Between Groups Study One	63
TABLE 9	Comparison of Mean Pre Test and Post Test Self-Concept Scores Between Groups. Study One	64
TABLE 10	Comparison of Mean Pre Test and Post Test Strength Scores Between Teacher Groups. Study One	66
TABLE 11	Comparison of Mean Pre Test and Post Test Self-Concept Scores Between Teacher Groups. Study One	67

TABLE 12 Comparison of Mean Pre Test and Post Test 12 Minute Run Scores Between Teacher Groups. Study One 68

TABLE 13 Comparison of Mean Pre Test and Post Test Composite Girth Measurements Between Teacher Groups. Study One 69

TABLE 14 Comparison of Leg Work Done Using the High Intensity and the Interval Circuit Programs. Study Two 80

LIST OF FIGURES

FIGURE 1 Study One Comparison of Percentage Gains Between Interval Circuit and High Intensity Groups on Experimental Variables. 59

FIGURE 2 Percentage Gains in Experimental Variables Between Teacher Groups. Study One 70

TABLE OF CONTENTS

Page

SUMMARY...iii

ACKNOWLEDEGEMENTS V

LIST OF TABLES vi

LIST OF FIGURES.....................................vii

Chapter

1. INTRODUCTION.....................................1.

Need for the Study - 2
Search for the Optimum Strength Program - 9
Purpose of the Study - 11
Definition of Terms - 12
Delimitations - Study One - 14
Limitations - Study One - 15
Delimitations - Study Two - 16
Limitations - Study Two - 17

2. LITERATURE REVIEW................................18

Effects of Weight Training Programs on
Cardio-respiratory Endurance - 18
Skeletal Muscle Hypertrophy - 21
The Athlete - 25
High Intensity Weight Training
Optimum number of Repetitions - 31
Slow Rates of Contraction - 32
The Stretch Factor - 33
Going to the point of Failure - 35
Motor Recruitment Patterns - 35
Site of Fatique - 37
The Equipment Factor - 38
The Eccentric Factor - 40
Principles of High Intensity
Weight-training - 41

3, RESEARCH PROCEDURES..............................42

Sample - Study One - 42
Sample - Study Two - 43
Dependent Variables - 43
Independent Variables - 44
Experimental Design - 46

Statistical Design - 47
Statistical Hypotheses - 48

4. ANALYSIS OF DATA.................................50

Effect of the Interval Circuit and High Intensity Weight Training Systems on the Experimental Variables Within Groups - 51

Post test Comparison of the Interval Circuit and High Intensity Weight-Training Systems on the Experimental Variables - 58

Post Test Comparison of the Teacher Relationship Effect on the Experimental Variables - 62

5. SUMMARY, CONCLUSIONS, DISCUSSION AND RECOMMENDATIONS 71

Summary - 71
Conclusions - 75
Discussion
The Anthropometric and Cardio-respiratory Variables - 76
Strength Gains - 77
The Process of Strength Development - 81
Self-concept Enhancement - 83
Recommendations - 87

6. LIST OF REFERENCES

7. APPENDICES

Tennessee Self-Concept Scale
High Intensity Weight Training Program Sheet
Interval Circuit Weight Training Program Sheet

CHAPTER I

INTRODUCTION

One of the most basic of all concepts in education is the ancient Greek credo - Mens Sana in Sano Corpore. The objective of developing a sound mind in a sound body has permeated public education throughout the centuries. T. H. Huxley (29) stated quite unequivocally that the liberally educated man was one whose " body is the ready servant of the will, and does with ease and pleasure all the work that, as a mechanism, it is capable of .... one who, no stunted ascetic, is full of life and fire. "

With the development of the teacher-specialist, the ever increasing body of knowledge, and the current HS1 (65) prescription which allows Ontario students to choose their own slate of subjects, the old concept of the integrated personality seems to have been lost in the shuffle. Now the only graduation requirements made of students entering Ontario high schools are that they select at least three subjects from each of the four areas of study: Communications, Social and Environmental Studies, Pure and Applied Sciences and the Arts. Although credits must be earned in English, Mathematics, Science and Canadian Studies, it is possible for a student to progress through high school without ever taking a Physical Education credit.

The effect that such freedom of choice has on the student's sense of what he is has not been adequately documented. If we are to accept Atkinson's (3) theory that one's sense of self is strongly influenced by the physical properties of his body, then it is possible that we are graduating students from our schools with very inferior notions about themselves and their abilities. This would be particularly true if such students were never exposed to proper physical education programs that encouraged the development of physical powers and skills essential to the normal growth and development of the adolescent.

NEED FOR THE STUDY

A positive self-concept is just another term for self-confidence, and the development of this factor has been the prime concern of those who wrote the Hall-Dennis Report (26). However, despite that report's emphasis on child-centred education, suicide rates in Canada increased from 91 in 1968 to 298 in 1977, an increase of 227% in a ten year span (39). In response to this alarming trend, the Ontario Ministry of Education cites improvements in a student's self-concept as one of the prime objectives of public education. P1J1 (72) states quite clearly:

> Education must respond to each individual's need to develop a positive sense of self, including a desire for competence and continuing self-development and self-evaluation.

A number of studies of the effect that activity programs have had on the self-concept variable suggest that Physical Education courses may produce significant gains in students' self-concepts. Dowell (14) reported a positive relationship between physical prowess and the physical self-concept, positive relationships between both strength and athletic achievement and the motivational self-concept and finally a positive relationship between physical fitness and physical self-acceptance. These conclusions were based on a survey done on 574 male freshmen at Texas A. & M. University. In this study, Pull-ups, two-minute sit-ups, and the 300 yard shuttle run scores were used to determine students' levels of physical fitness. The seven measures of the self-concept measured were intellectual, emotional, physical, social, Motivational, and self-in-relation-to-self and self-in-relation-to-others.

Ismail and Trachtman (30) found that middle-aged men involved in a regular exercise program became more self-sufficient, resolute, stable, and imaginative, presumably because of the regular exercise pattern that they adopted.

Sharp (57) discovered that aerobic fitness correlated positively with the more favorable scales on the Minnesota Multiphasic Personality Inventory (MMPI). Sixty-five male college students participated in an aerobic conditioning class that met for 45 minutes twice per week. Although subjects who scored highest initially on VO_2max. and 12-minute run scores gained the most pshchologically by the end of the fitness training session, Sharp concluded that changes in aerobic capacity produced positive score changes on some scales of the MMPI for all males participating in the program.

Self-concept enhancement has been particularly effective in studies dealing with the disadvantaged. Collingwood's (9) matched pair study included 50 rehabilitation clients, 25 of whom were exposed to a four-week program of sprints, calisthenics, and agility drills for one hour, five days per week. Subjects were encouraged to increase distances and repetitions constantly every day. Subjects exposed to the exercise program demonstrated greater significant increases in physical fitness, body attitude, self-acceptance, and positive physical, intellectual and emotional-interpersonal behaviours than did control subjects unexposed to such programs.

Elstein (16) found that an individualized, structured program of basic skills brought about significant gains in physical fitness, social adjustment, and self-concept in learning disabled children. Unterseher's study (70) of physically weak boys resulted in significant improvements in self-concept, peer popularity and strength as a result of a special bodybuilding program. Sorenson (62) also found a relationship between strength and self-concept in his study of Grade Seven boys with poor self-concepts. His weight-training group made significantly better gains ($P<.01$) in strength and self-concept than did his control group.

The reasons for such dramatic changes in self-concept can only be understood after examination of a typical scale designed to measure such a variable. Fitts (17) describes five facets of the self-concept in his scale - the physical self, the moral-ethical self, the personal self, the family self, and the social self. His battery of questions attempts to assess how the individual sees or identifies himself in each of these facets, how he accepts what he sees, and how he sees himself behaving or acting in each of these facets.

Dowell (14) has proved that a positive relationship exists between physical prowess and the physical self-concept. Hence, an increase in physical strength should enhance the physical component of a student's self-concept.

Zion (74) has suggested that a person's attitudes concerning his conception of himself will influence and be influenced by his view of his physical appearance. The emphasis is on what a person thinks he is, regardless of what he is in reality. Zion found a significant ($P. < .01$) linear relationship between self-description and body description and ideal self and ideal body. Thus those subjects who rated themselves as physically attractive, agile, muscular, strong, etc. tended to have high self-concepts; whereas, those who rated themselves as ugly, weak, awkward, etc. tended to have low self-concepts.

If an increase in strength will improve one's physical self-concept and if there is a strong correlation between physical self-concept and total self-concept, it follows that an increase in physical strength is likely to increase one's total self-concept. Since strength-training tends to improve posture and muscle size (36,46,48), it is conceivable that strength gains might also be accompanied by improvements in the Personal Self facet of total Self-Concept. According to the Purdue Opinion Panel (32), physical appearance is the major cause of inferiority feelings in high school students, almost twice as important, in fact, as lack of social skills. Hence, it is possible that the improvement in muscle tone, posture and hypertrophy that accompanies most weight-training programs could go a long way towards removing these feelings of inferiority so common in young people today.

The third reason why strength gains might bring about positive changes in students' self-concepts is related to the effect that such gains have on the Social Self facet of Self-Concept. Singh (58) felt that the most "significant other" for high school students was their peers. He felt that an adolescent's peer group had an even greater impact on self-concept development than did parents, although parents came a close second. Such a finding suggests that the degree to which a student was popular with his peers would have a strong bearing on his concept of Social Self. Both Dunn (15) and Clarke (9) have found significant ($P < .01$) correlations between measures of strength and popularity. Dunn found that static strength in both arms and legs had the highest relationship to peer popularity, particularly in Grades Seven through Eleven.

Thus it is conceivable that an improvement in physical strength could go a long way towards improving not only the Physical Self and Personal Self facets of total Self-Concept, but also the Social Self component as well, particularly if such strength gains become apparent to those all-important significant others- one's peers.

The role of the teacher in self-concept enhancement has not been adequately documented. Despite the emphasis placed on the development of this quality by the Ontario Ministry of Education, no studies could be found to prove that self-concept enhancement was indeed going on in the traditional classroom setting. Fitts (17) felt that this lack of change was quite normal because of the very basic nature of the self-concept. It does not readily change, even though one begins to feel and act differently. Test-retest reliability coefficients for Total Positive Score averaged out at .92 even over long periods of time. Nevertheless, there is considerable evidence that people's concepts of self do change as a result of significant experiences. Crouse (12) suggested that a student's self-concept could be significantly altered by his teachers. He felt that the essential ingredient involved in any positive change was a quality of interpersonal relationships - one in which the teacher's and the student's highest expectations were realized. Testimonial letters from the parents of the boys in the Sorenson study (62) would suggest that the self-concept gains these boys made were the result of a very significant relationship between these students and their teacher.

Rogers (52) felt that the effective teacher was really a facilitator of learning, a genuine person who was willing to discard the stereotyped teacher role when it conflicted with the way he really felt. He felt that the effective teacher prized his students, trusted them and accepted them for what they were. For Rogers, the good teacher's most outstanding quality was a capacity to empathize with his students and to see the world as they saw it.

Such teacher qualities can be measured by students themselves using the Barrett-Lennard Relationship Inventory. (4) This inventory uses a six point scale to evaluate the teacher's congruence, prizing and empathy qualities that Rogers felt were the core of an effective student-teacher relationship.

If such qualities are really essential for self-concept enhancement, one must begin to wonder if, in fact, such a change is possible in contemporary education. One study cited by Rogers revealed that the average therapist's score on this inventory was 108. The four most adequate teachers in the study scored 34, and the lowest rated teacher received an average score of 2.

Aspy's (1) study involving Grade Three reading classes revealed that children whose teachers had the highest degree of genuineness, prizing and empathy showed significantly greater gains in reading achievement than did students whose teachers lacked these qualities. Teacher ratings were done by objective examiners and were based on an assessment of randomly selected recordings of teacher interactions with their students.

Such studies reveal the need for an investigation that attempts to measure to what extent changes in self-concept are due to teacher variables and to what extent such changes are in fact the product of a gain in strength. The present study is an attempt to do just that. NB

THE SEARCH FOR THE OPTIMUM STRENGTH TRAINING PROGRAM

The second major reason for undertaking this study is to find a program that optimizes strength gains. The incredible growth of strength-training techniques over the last ten years necessitates an up-to-date review of current research, theory and practise if one hopes to keep pace with current trends in this field. Counselling students regarding their strength programs can be far more effective if one can provide efficient, practical solutions to the strength problems of today's students.

It has been the author's impression after working with hundreds of weight-trainers over the past 25 years that much of the time spent in conventional weight-training programs is an enormous waste of time. Weight-trainers, particularly, tend to believe that if one hour of training will produce certain results, two hours will produce twice that amount; yet recent research (5,10,46) done on time spent training does not confirm that belief.

Connor (10) has proved rather conclusively that an 18 minute Interval Circuit weight-training program will produce equal gains in anthropometric measures, equal or greater strength gains and significantly greater gains in cardiovascular endurance than would a 60 minute set system program using the same exercises, sets and repetitions. Discovery of such time-saving and effective programs could have a profound influence on the development of strength, endurance and hypertrophy in the physical education classes of this country, particularly when limited time is a factor. If only 11 minutes of actual movement occurs in an average physical education class (24), some attempt must be made to increase the intensity of the program if any improvement in aerobic or anaerobic power is to occur.

With these factors in mind, the author attempted to study two short duration programs that had been found to be effective by other researchers and to determine to what extent these programs could produce improvements in strength, and self-concept in a minimum amount of time. The Interval Circuit system was developed by Connor (10) and was formulated by using basic principles of weight-training, circuit training and interval training. The High Intensity system was developed from the basic principles espoused by Riley (51) and Mentzer

look up Fitz
Mentzer
Connors Riley

(40) and attempts to maximize repetitions by incorporating concentric, eccentric and isometric forms of contraction at a slow rate and going to the point of failure.

Mentzer claims that the multi-set system is a waste of time. He recommends one set of an isolation exercise followed immediately by one set of a compound exercise that works the same muscle group. Thus if six muscle groups were worked, it would be possible to complete a High Intensity program in 12 minutes rather than the 18 minutes required in Connor's Interval Circuit program. If the High Intensity program could equal the results achieved with the Interval Circuit, we would have a new program that would incorporate much of the contemporary strength research as well as one more efficient, effective method of developing fitness in the classroom.

PURPOSE OF THE STUDY

The main purpose of this study was to compare the effects of Interval Circuit and High Intensity weight-training systems on muscular strength, cardiovascular endurance, girth measures and self-concept of high school boys. A second purpose was to investigate the effectiveness of two popular High Intensity systems - that described by Riley (51) and that described by Mentzer (40). Since Riley and Mentzer differed significantly in some of their training prescriptions, it was necessary to conduct two studies - one to investigate the effectiveness of

Riley's system which we will call Study One, and one to investigate the effectiveness of Mentzer's system which we will refer to as Study Two.

DEFINITION OF TERMS

Cardiovascular Endurance (C.E.) - The ability of the body to supply oxygen to the tissues and to use it, as determined by Cooper's 12 Minute Aerobic Run Test (11).

Compound Exercise - An exercise designed to work a particular muscle in such a way that auxiliary muscle groups are mobilized to assist with the action involved.

Concentric Contraction (C.C.) - Shortening of the Prime Mover during the active phase of an exercise when movement occurs.

Eccentric Contraction (E.C.) - Negative contraction or lengthening of the Prime Mover when lowering of the resistance is actively resisted throughout the range of joint motion.

High Intensity Weight Training (H.I.) - A system of weight-training involving 6 - 12 repetitions done to the point of failure where a 4 sec. C.C. is followed by a 4 sec. E.C. with little or no rest between sets involving the same muscle group.

Interval Circuit Weight Training (I.C.) - In this study, a system of weight-training involving 3 circuits of 4 - 6 repetitions of 6 different exercises performed one after another using a 1 minute work-rest interval for each exercise.

Isokinetic Contraction (I.K.) - Maximal concentric contraction throughout the range of joint motion at a predetermined speed of movement.

Isolation Exercise - An exercise designed to work a particular muscle group exclusively in such a way that mobilization of auxiliary muscle groups was largely prevented.

Muscular Strength (M.S.) - The maximum effective force that a muscle can exert once (1RM). This variable was assessed dynamically by the 1RM method in leg press, seated military press, leg curl, bench press, pulldown and the arm curl on the Universal weight-training apparatus. Total composite strength was recorded as the total maximum number of pounds lifted through one full range of motion in each of these tests. Such tests really measure strength at the weakest point in a movement only. In Study Two, M.S. was determined by recording 1RM efforts in the leg press only.

Point of Failure (P.F.) - The point at which the muscle group being worked loses its power of voluntary contraction through the concentric phase using the current load. The objective here is to mobilize a maximum number of motor units before this point of failure occurs.

Self-Concept (S.C.) - A composite of self-perceptions involving the physical, moral-ethical, personal, family and social self in terms of how the subject sees himself in each of these facets, how he accepts what he sees, and how he sees himself behaving or acting in these spheres. Since only the total positive score on the Tennessee Self-Concept Scale (TSCS) was used in this study, S.C. scores may be best regarded as measures of self-esteem.

Teacher Effectiveness (T.E.) - The teacher's level of empathetic understanding, regard for students, congruence and willingness to be known as measured by the Barrett - Lennard Relationship Inventory (BLRI).

DELIMITATIONS - STUDY ONE

1. This study included 70 Year One students at Highland Secondary School.
2. The study began on September 12. 1978 and ended November 17, 1978.
3. Four experimental groups of ten to twelve students each were assigned the experimental treatments. Two were assigned to the I.C. program while the other two were assigned to the H.I. program.
4. Treatment consisted of 9 -15 consecutive training periods one every other school day.
5. Subjects in the experimental groups consisted of Physical Education students who scored in the twelve lowest percentiles of total positive score on the TSCS.
6. The remaining members of two of these classes served as a quasi-control group although it was not possible to isolate this group from the experimental treatment. (Table 1)
7. All experimental groups performed the same exercises, with

the I.C. group completing a total of 15 repetitions in approximately 18 minutes and the H.I. group completing a total of 12 repetitions in approximately 12 minutes in each training session.

LIMITATIONS

1. Initial mean scores indicated that the two training groups did not differ significantly in terms of S.C. scores; however, the groups differed significantly ($P < .05$) in pretest C.E. score and in mean pretest M.S. scores ($P < .01$). (Table 5)
2. Since the study was conducted during normal Physical Education class time, it was not always possible to rigidly control the treatment of the two variables; hence, total supervision of the experimental treatment was not possible.
3. Although the other half of classes 151-03 and 151-04 acted as a control group, this group did take part in an unsupervised weight-training program during that half of the period that the experimental group took the regular Physical Education program.
4. Treatments were assigned to the groups on a random basis but in order to equalize the groups in terms of self-concept it was not possible to assign the students to the groups in a random fashion.
5. One of the experimental groups, 151-05, was not under the

direct control of the researcher conducting this study. The degree to which the group was forced to comply, therefore with the experimental prescriptions is open to question.

DELIMITATIONS - STUDY TWO

1. This study included 39 Years One and Two occupation students at Highland Secondary School.
2. The study began November 20, 1979 and ended February 14, 1980.
3. Two experimental groups of ten students each were assigned randomly to either the I.C. or Mentzer's H.I. weight-training program.
4. Treatment consisted of two sessions of training from November 20 to December 19 and from January 3 to February 14 for an average total number of 15 training sessions, one approximately every other school day.
5. Subjects consisted of all the male occupational students in the school who were in regular attendance in the Physical Education program. Students were assigned to groups according to a computer printout which equalized the numbers and ages of the students in each group. There was no significant difference initially in mean strength scores between the two groups.
6. Since there were two teachers in charge of this class,

much closer supervision of the experimental treatments could be made by this researcher than was possible with the first study.

7. Different exercises were performed by each group but the total number of repetitions per body part were approximately equal with the I.C. group completing an average of 14.7 repetitions of leg exercise and the H.I. group completing an average of 13.8 repetitions of leg exercise per training session. (Table 15)

LIMITATIONS

1. Because of the irregular attendance pattern of many of these students, it became necessary to drop approximately 20 students from the study, ten from each group. This is the reason of the comparatively small number of subjects in each group.
2. Two breaks in the continuity of the study occurred - one for seven days in November during which students were writing exams and one in December for approximately 12 days during which students were excused for the Christmas holidays. In addition to these breaks, some of the senior students were excused for one week for a work-experience program.
3. Because of the small group involved and the irregular attendance patterns of these students, it was not possible to establish a control group for this study.

CHAPTER 2

LITERATURE REVIEW

This review will consist of two major parts. The first part will deal with major findings to date regarding the effects of weight-training. The second part will deal with studies related to the development of High Intensity weight-training principles.

EFFECTS OF WEIGHT-TRAINING PROGRAMS

CARDIO-RESPIRATORY ENDURANCE (C.E.)

The influence of isometric and isotonic training on the development of C.E. has not been conclusively determined. Clarke (7) feels that these forms of exercise do not contribute appreciably to aerobic power while Swegan (67) found that isometric training produced a significant increase in bicycle ergometer riding time and a reduction in pre-exercise pulse rates, diastolic and systolic blood pressures and blood lactate concentrations.

In a study done by Capen (6), a weight-training group which was superior in almost all initial fitness scores matched a control group's increase in the 300 yard shuttle run despite the fact that the control group was trained on a specific endurance type program.

Gettman's study (19) comparing the effects of circuit strength-training and jogging revealed that both programs were effective in producing significant increases in treadmill times and $\dot{V}O_2$ max in both absolute and relative terms. Both programs also produced significant decreases in maximal heart rate. Although circuit strength-training produced significant improvements in $\dot{V}E_{max}$ and resting heart rate, the jogging program following the circuit training program did not produce significant changes in these variables.

Gettman also found significant reductions in body fat percent, fat weight, sum of six skinfolds and waist girth as a result of circuit strength-training, as well as significant increases in lean body weight, biceps girth and isotonic and isometric strength measures.

The jogging program which followed circuit strength-training (CST) resulted in significant decreases in bench press strength, isotonic shoulder press and the arm curl. Gettman reminds us though that the 3% increase in aerobic capacity as a result of CST is a modest increase compared with the 15 -20% increase found in running programs. He also suggests that part of this 3% increase in $\dot{V}O_2$max. is due to the significant increase in lean body weight. Much of this increase might simply be the result of increased muscle mass which would allow the subject to stay on the treadmill longer because of the increased functional capacity of the leg muscles.

Since CST maintained fitness levels during the eight weeks following the eight week jogging program, CST could possibly maintain running potential in terms of cardio-respiratory functioning if a person incurred severe leg soreness or injury during a jogging program.

The effect of a conventional set system of weight-training on C.E. has not been as thoroughly studied, although MacDougall's study (37) suggested that heavy resistance training might be detrimental to endurance performance in bodyweight supported activities. He found that such training reduced the oxidative potential per total muscle mass. A significant ($P < .05$) 26% reduction in mitochondrial volume densities and a significant 25% reduction mitochondrial to myofibrillar volume ratio as a result of five months of heavy resistance training using the set system was documented in this study.

Such reductions in percentage values of mitochondria were not restricted to fast twitch fibers. Although fast twitch fiber area increased by 33% and slow twitch fibre area increased by an average of 27%, this increase was accompanied by a non-significant 12% increase in cytoplasmic volume density and a significant 83% increase in lipid. This would suggest that heavy resistance training leads to a dilution of mitochondrial volume density through an increase in myofibrillar size with hypertrophy. Since demands made on the muscle during heavy resistance training in sets lasting as long as 48 seconds are done so at loads near 70% MVC where occlusion of blood flow to the active muscle occurs, the function of mitochondria as a facilitator of oxidative metabolism must virtually disappear.

Recent animal studies (35,45) suggest that any improvement in C.E. as a result of CST may be the result of hypertrophy of the heart muscle following such training. Cats conditioned to 2 -9 months of isometric exercise produced significantly greater ($P < .001$) heart weight to body weight ratios than those of control cats (45). Left ventricular wall thicknesses increased as much as 14 -29% in these cats. In his study of competitive athletes, Longhurst (35) discovered that competitive weight-lifters and long distance runners had significantly increased left ventricular masses when compared to their respective controls. ($P < .05$) It is possible therefore that weight-training may bring about hypertrophy of the heart muscle in a manner similar to the process whereby skeletal muscle hypertrophy occurs.

SKELETAL MUSCLE HYPERTROPHY

The most massively muscled men of our time are professional bodybuilders. Their degree of hypertrophy, lean body mass and low body fat is extreme. Pipe s' (49) study of 20 top bodybuilders including Arnold Swarzenegger revealed that not only do these men have an unusual degree of muscle hypertrophy;

they are also extremely strong. The average maximal leg press for the 20 bodybuilders was 801.3 pounds. The average bench press was 407.5, biceps curl - 196.9 and shoulder press - 275.3. Such lifts are doubly impressive considering that the average bodyweight of these men was 198.82 pounds.

Such average lifts are very close to the personal records of the strongest competitive athletes in the world today - the powerlifters. Terry Todd (69), once the world champion in the superheavyweight class rates Larry Pacifico and Ron Collins as the world's best powerlifters in terms of their overall total performances. Pound for pound, these two gentlemen are probably the strongest men in the world today in terms of overall body strength. Larry Pacifico at 242 pounds bodyweight bench pressed 610, squatted with 780 and curled 225 with his back against the wall. He also pressed 315 from behind his neck three times consecutively. These were Larry's best all time records.

At 193 pounds bodyweight (the average bodyweight of the bodybuilders in Pipe's study), Pacifico's best bench press was 440 just 32.5 pounds better than the average bodybuilder's press of 407.5. Ron Collins, Todd's other top powerlifter, bench pressed a personal best of 418 at a bodyweight of 181 while Mr. Olympia, Franco Colombu bench pressed 500 for a personal best at a bodyweight of 175. Colombu's best dead lift at this weight was 700 while Collins did 722. (60)

It is obvious therefore that the top bodybuilders are almost as strong as the world's top powerlifters, yet their objectives in training are quite different. Bodybuilders seek increased muscle size whereas lifters are primarily concerned withe the amount of weight they can lift. While Olympic lifters concentrate on the style and technique of lifting heavy weights overhead, powerlifters are primarily concerned with the development of power in the major muscle masses of the body, i.e. the legs, back and chest.

Since a number of researchers (36,46) have found increases in muscle hypertrophy accompanying increases in strength, a review of the physiological changes in hypertrophied muscles may help us to understand the mechanisms involved in strength development. Muscular hypertrophy may be developmental, work-induced or stretch-induced. Fowl studies by Laurent (33) and Sola (61) revealed increases in muscle weight by as much as 200% as a result of stretching the fowl's wing muscles. Goldberg (20) found that the average diameter of hypertrophied muscle fibers was 29% greater than that of control fibers. MacDougall (36) reported a 28% increase in maximum elbow extension strength, a 39% increase in Creatine content and a 66% increase in glycogen in hypertrophied muscles. After six days of hypertrophy, Laurent (33) detected a 203% increase in RNA, an 83% increase in DNA and a 44% increase in protein content in hypertrophied fowl muscle. Goldberg (20) discovered both a greater initial uptake of amino acid and a higher intracellular content in the hypertrophied rat soleus.

Sciaffino (56) found a four-fold increase in the number of nuclei in the muscle satellite cells and interstitial cells of hypertrophied gastrocnemius muscle. Leblond (34) suggests that these satellite cells are actually the source of new muscle fiber nuclei.

More recent research (21,22,23,61) tends to suggest that increases in muscle size may be the result of hyperplasia as well as hypertrophy. In one of Gonyea's studies (21), he discovered a 19.3% increase in the total number of fibers of the weight-trained flexor carpi radialis muscle (FCR). His histological picture shows fibre splitting in both fast and slow twitch fibres of the exercised limb. Gonyea's most recent study (23) with weight-lifting cats revealed a 44% increase in the weight of the exercised muscle due to fibre splitting and hypertrophy. He also discovered that fibre splitting only occurred when the intensity of the exercise was high (when the weight lifted was 1 Kg. or higher). In the group of cats which lifted less than this amount, no fibre splitting occurred.

Gonyea also discovered a decrease in event time or time required to lift the weight as the weight lifted increased. It was for this reason that he hypothesized that it is the force generated from rapid movement that promotes fibre splitting during heavy resistance training. He noted a rapid decrease in event time after the 1.04 Kg. intensity level was achieved. He reported a 20.5% increase ($P \leq .002$) in the number of muscle fibres of the FCR of cats working at the high intensity level.

Sola's (61) group of chickens experienced an average gain of 70 fibers per week as a result of stretching these fibers with weights attached to the chickens' wings. If such a growth of new fibres is common to the increased size of human muscles, the recruitment of such fibres could have a profound effect on strength development. The significantly smaller muscle fibres in the deltoid muscles of elite female swimmers that Gonyea (23) mentions may very well be the result of fibre splitting caused by the rapid acceleration of the arms against the resistance employed in their dry-land training program.

WEIGHT-TRAINING AND THE ATHLETE

Clarke (7) and most coaches today regard weight-training as an essential aspect of the athlete's conditioning program. The myth that weight-training would make the athlete "muscle bound" has been refuted by a number of studies (7,48,58) that show that speed is enhanced rather than retarded as a consequence of strength development. Clarke (7) felt that both isometric and isotonic forms of strength training could produce improvements in many motor and sports performances. Progressive weight-training programs tended to be superior in this regard particularly in baseball, swimming, football, basketball and track.

Despite such wholesale endorsements of weight-training as a valuable conditioner, the development of new types of training machines has caused coaches to become somewhat confused over which type of training to prescribe for optimum strength development. Garhammer (18) for example, believes that high intensity programs that emphasize slow movement fail to activate powerful fast-twitch motor units which come into play during explosive movements. While this may be true for slow submaximal types of contraction, it is very doubtful that only slow-twitch motor units are recruited during maximal or near maximal contractions. At this point one would expect all available motor units to be recruited particularly if the contraction goes to the point of failure.

Warmolts and Engel (71) revealed that motor units activated at low tensions usually have a lower starting frequency (6-10/sec.) and show a greater frequency range than those active only at higher tensions. He also found that these early-recruited slow-twitch units had a maximum firing frequency of 18-20/sec. while the fast-twitch units which were normally activated during sudden or vigorous contraction had peak firing frequencies of 16-50/sec.. These fast-twitch fibers tended to fire only in brief bursts lasting from 0.5 - 5.0 sec.

Grimby and Hannerz (25) found that slow-twitch motor units were the only ones recruited if a submaximal sustained voluntary contraction was planned; whereas, fast-twitch motor units tended to be recruited first if the contraction was to cease immediately.

Desmedt and Godaux (13) however, feel that the recruitment order (slow to fast) is the same regardless of velocity of movement. The key factor appears to be the percentage of maximal strength that is taxed. They found that during slow ramp contractions, motor units were recruited in a consistent order depending on the level of force exerted. In brisk ballistic contractions, the recruitment order didn't change but because of the greater speed of the fast-twitch motor units, firing in the phasic muscle fibres might even precede firing in the tonic fibres.

A number of researchers (18,48,66) feel that the use of isokinetic machines is the best way to get athletes to exert greater forces at higher movement speeds. Stevens (66) felt that isokinetic power training had a greater effect on performance and mechanics than did training for absolute strength. Unfortunately, no level of significance was cited for any of his findings.

Wolfe (73) felt that a combination of both slow and ballistic exercises would produce the desired effect in athletics. His reasons for saying so however, are not physiologically sound. Slow training will not produce increases in capillary size but it should be most effective in generating increases in concentric contraction force. This should stimulate muscle adaptation whereas fast training might train the nervous system to produce greater forces at higher contraction speeds. Wolfe's contention that slow contractions should be done to build a base for ballistic exercises has no scientific basis in the literature related to this topic.

Hellebrandt (28) felt that both types of training (i.e. slow and fast) were equal in developing work capacity if one equated the work done per unit of time. She found that high power programs (high contraction speed, low load) developed the same results as low power programs (slow contraction speed, high load) providing the work done (load x repetitions x time) was the same. In this case the force generated in the two programs was similar; that is, the light weight was accelerated by a larger force to equal the force applied to the heavy weight. However, if the weight is too light, it is impossible to apply sufficient force to equal the force generated when moving heavy loads.

Moffroid's isokinetic study (44) tended to suggest that speed of contraction was specific to the rate at which one trained. Although the only program which yielded significant gains in peak torque was her slow maximal 6rpm program, her fast maximal exercise group had slightly better scores at higher velocities of contraction. Those who trained at 18rpm had a mean increase in peak torque for the quadriceps muscle of 15.6 Newton-Meters; whereas, those who trained at 6rpm had a mean peak torque gain of 8.4 Newton-Meters at the 18rpm velocity of contraction.

Pipes and Wilmore (48) demonstrated that isokinetic procedures were superior to isotonic procedures in the development of strength and improved motor performance but this study is currently suspect since Wilmore dissociated himself from the study when he learned that some of the statistics were inaccurate. Thus the data presented here might actually be false despite the fact that it had been considered as the most convincing of all the isokinetic studies done at that time. In this study, both the isokinetic high speed and slow speed groups demonstrated significant ($P < .05$) improvements in 40 yard dash times, softball throw and vertical jump. No significant improvements in these measures occurred in the isotonic group. Isometric, isotonic, and isokinetic strength gains were also purported to be superior in the isokinetically-trained groups.

Even if Pipes' data were true, the design of his study was poor because a good isokinetic program was compared to a poor weight-training program. Whereas each contraction was maximal in the isokinetic program, rarely more than one or two repetitions were maximal efforts in the weight-training program. Pipes felt that the major reason for the superioriy of the I.K. training procedures was that they allowed muscle groups to generate more force while the motor task was being performed. However, according to the Hellebrandt (28) formula, the obvious reason for the superiority of the I.K. procedures is the fact that these subjects are training with maximal resistance whereas the weight-training group is working with 75% of their 1RM maximum for most of their training sessions. Pipes also neglects to state how many training sessions his weight-trainers missed because of injuries sustained in this program. Thus the two programs are hardly a fair comparison in terms of contraction intensity.

It is apparent from these studies, that the value of high-speed training to develop strength has not been adequately documented. Although some coaches (16,18) feel that high speed strength-training is the only way to activate fast-twitch motor units, no scientific basis for most of these claims can be found. Thus, we must look at alternate training theories, if we are to discover the keys to optimum strength development.

HIGH INTENSITY WEIGHT-TRAINING

It is apparent from Moffroid's (44) study, that optimum strength gains can be secured only when training at rather slow rates of speed. The only program in her study which yielded significant gains in peak torque was her slow maximal 6rpm program. ($P. < .01$) Groups training at faster rates did not make significant gains in peak torque.

An examination of muscle exposed to such programs indicates that factors other than recruitment patterns are at work in the exercised muscle. Significant changes in the chemical composition of muscle fibres have been demonstrated by MacDougall (36) as a result of heavy resistance training using the set system. Significant increases in resting concentrations of creatine (39%), creatine Phosphate (22%), adenosine triphosphate (18%) and glycogen (66%) occurred in his subjects as a result of five months of heavy resistance training of the human triceps brachii muscle. MacDougall's more recent study (37) suggests that such increases are not limited to fast-twitch fibres. He found a 33% increase in fast-twitch fibre area and a 27% increase in slow-twitch fibre area in this study.

OPTIMUM NUMBER OF REPETITIONS

To maximize such increases in energy supply, Riley (51) insists that high levels of contraction intensity must be inherent in the exercise design. The original research in this area concentrated primarily on determining what is the optimum number of sets, repetitions, load and frequency of training necessary to achieve this level of contraction intensity. Berger (5), Clarke (7) and others (44,46) have found that the training program that would produce optimum gains in strength was one where training occurred at least three times per week at an intensity level of 3 sets of 4-6 repetitions arranged so that a period of 48 hours occurred between training sessions involving the same muscle group.

HIGH INTENSITY AND SLOW RATES OF CONTRACTION

The Moffroid study (44) mentioned earlier does suggest that slower rates of contraction are more effective in developing strength than are fast explosive types of movements. Astrand (2) states that tension decreases in a muscle as the speed of shortening increases. Training at faster rates (18rpm) with lighter loads was more apt to increase muscular endurance than muscular force. (44)

Riley (51) recommends a slow (6sec.) contraction time for optimum results when going to the point of failure at the 8-12 repetition range. Mentzer (40) however recommends 6-9 slow repetitions when going to the point of failure. Both men feel that a slow concentric and eccentric contraction should be performed in each repetition. Mentzer also recommends 2 additional forced repetitions and 3 negative repetitions where a partner assists the subject through the concentric phase before the weight is actively lowered eccentrically.

If the objective of such a program is to work the muscle to the P.F. , perhaps 2 three sec. repetitions may be just as effective as 1 six sec. repetition providing of course that the contractions are not ballistic types that rely on inertia to propel the weight through the range of joint motion once the initial thrust is applied.

THE STRETCH FACTOR

Other current researchers (20,33,61) support the idea that stretching a muscle will also increase contraction intensity to the point where significant gains in strength and size may occur. Goldberg (20) found that amino acid transport to animal muscles increased if the muscle was stretched 10-15% beyond its resting length prior to electrical stimulation. In fact, stretching a rat's diaphragm for one or two hours without any electrical stimulation also increased amino acid uptake in the muscle.

Sola (61) also felt that stretch was the cause of hypertrophy and hyperplasia in muscle. By denervating the anterior latissimus dorsi muscles (ALD) of the chicken and by adding 200 grams to the left wing, Sola was able to increase the wet weight of the muscle by over 140% during an 8 week period. Adding 200 grams to the wing where innervation remained intact increased hypertrophy by 200% over the same period. The difference between such active and passive stretching appears to be that passive stretch may cause longitudinal muscle growth whereas active tension is more likely to cause cross-sectional growth.

Laurent (33) induced similar results in the ALD of the adult fowl by feeding the birds a high protein diet of pellets containing 35% protein, giving daily injections of 100 mg. of l-leucine and by attaching 180 gram weights to the birds'elbow joints. After 6 days of hypertrophy, the net weight of the muscle had increased by 74%, protein content increased by 44%, DNA by 83% and RNA by 203% compared with the contralateral control wing.

Since it is difficult to stretch intact human muscle to any extent, the best that can be done is to incorporate a maximum extension and flexion of the joints being worked into the exercise design. Astrand (2) found tension to be maximal in a muscle when it was stretched 20% beyond its resting length. Thus contraction intensity can be heightened if one follows a strict exercise form that incorporates complete extension and flexion of the joints being worked. It seems obvious then that the slower the contraction time or the greater the number of repetitions, the more intense will be the stretch effect on the cross-bridges between the actin and myosin filaments, particularly if heavy eccentric contractions are employed. Since eccentric contractions are not employed in isokinetic training however, it is difficult to determine to what extent this stretch effect is operative in strength development.

GOING TO THE POINT OF FAILURE

A key component in the development of the high-intensity system is going to the point of failure or stressing the muscle to the point where all available motor units in the muscle are mobilized (28). Mentzer felt that exercises initiated with a sudden jerk and continued rapidly to completion apply resistance only when the muscle is partially flexed. Repetitions that are begun and carried through to completion in a relatively slow and deliberate manner apply resistance during all phases of contraction.

In this study, two methods of going to PF were utilized. In Study One, one set of an exercise was followed using 9-12 repetitions. In Study Two, 2 exercises involving the same muscle group were used. In this study, 6-9 repetitions of one exercise were followed immediately by 6-9 repetitions of the second exercise. The same effect could also be achieved by simply lowering the resistance and continuing with the same exercise.

The ultimate objective in all three approaches is the same - failure of the muscle group to contract after mobilization of all available motor units has been realized.

FAILURE AND MOTOR UNIT RECRUITMENT PATTERNS

Very little information is available on motor unit recruitment patterns when the muscle is forced to the point of failure as a result of H.I. contractions. Stephens and Taylor (64) found that during a sustained isometric contraction, a 50% loss of strength and a 50% reduction in EMG activity occurred during the first minute of contraction time. Although the early recruited units were small and fired at low frequencies throughout the minute of contraction time, their failure was probably caused by fatigue of the contractile element. The larger later-recruited units fired at high frequencies and probably fatiqued rapidly at the neuromuscular junction (NMJ). For example, adductor pollicis motor units normally firing at 100/sec. could fall to 30% of normal amplitudes and to a frequency of 20/sec. in 30 seconds of sustained M.V.C. The speed with which muscles fatigue in maximal contractions emphasizes the fact that a task at the limit of a subject's strength must be accomplished immediately or not at all.

When contraction started from a submaximal value (as in the case with most weight-training), force might be maintained for some while. During this time, Stephens and Taylor found that E.M.G.activity actually increased. Since the ratio between E.M.G. and force exerted rose after the first 30 seconds of contraction and continued to rise until the third minute, the site of failure must have been the contractile element. This was compensated for by progressive recruitment of units and an increase in firing frequency until the contraction effort was truly maximal. At this stage, the discharge frequency of units was so high that NMJ failure may have been caused by exhaustion of transmitter stores.

In High Intensity weight-training as we have defined it, and as advocated by Riley and Mentzer, subjects train at 66-75% of 1RM and although isotonic contraction is occurring, the concentric phase may last as long as 4 sec. and the eccentric phase as long as 6 sec. Thus a set of 6 of these maximized contractions would last between 36 and 48 sec. Since going to failure is crucial in this program and since complete occlusion of blood flow occurs at this level of contraction intensity, subjects are training largely in a a hypoxic state where the rate of anaerobic glycolytic metabolism increases to supplement the generation of ATP from the breakdown of creatine phosphate in order to supply energy for contraction.

As the force generating capacity of the fibres in one motor unit declines, additional motor units, and not isolated fibers, as Riley suggests, must be recruited to maintain the desired level of force.

SITE OF FATIQUE IN HIGH INTENSITY WEIGHT TRAINING

It would appear then that the site of fatigue in high intensity weight-training is the muscle itself since fatigue seems to occur within the first three minutes of a sustained concentric, eccentric set. The decrease in intracellular pH due to the accumulation of lactic acid reduces the rate of anaerobic glycolysis by inhibiting the glycolytic enzymes-phosphorylase and phosphofructokinase. Thus the glycolytic ATP regeneration ceases. The lowered PH of the muscle also interferes with the normal binding of the calcium ions to Troponin, and hydrogen ions take their place. Thus a greater concentration of calcium ions is required for activation of myofibrillar ATPase. This results in a reduction in the rate of degradation of ATP. Presumably then, working the muscle to the point of failure will force the muscle to compensate by increasing its supplies of ATP, calcium and glycogen and by progressive recruitment of more and more powerful fast-twitch motor units.

HIGH INTENSITY AND THE EQUIPMENT FACTOR

As has already been noted, the advantage of the isokinetic machine is that it allows for maximal contraction throughout the range of joint motion, not just at the beginning of the exercise as is the case with most free barbell exercises. Astrand (2) found that the tension in a muscle was maximal only when the muscle was stretched 20% beyond its equilibrium length. Tension decreased at longer and shorter muscle lengths, although skeletal leverages improve to compensate for this decrease in tension. Thus in some movements, one is strongest at the beginning of the exercise while in others one is strongest in the middle or at the end of the contraction.

If maximal tension, therefore, is to be maintained throughout the range of joint motion, some way must be found to maximize resistance throughout the range of joint motion. Since isokinetic machines provide for this maximal resistance throughout the range of motion, they appear to be the best yet designed to provide for maximum resistance throughout the concentric phase of muscular contraction.

The development of the Universal Gym and the Nautilus machines has made it possible to increase or decrease resistance as the joint angle changes in a wide variey of exercises, while still allowing for concentric and eccentric types of contraction to occur. Such a gain in contraction intensity should allow the contracting muscle groups to generate more force while the motor task is being performed even though the speed of training does not equal that attained in high speed isokinetic training. A speed of 24°/s which is common to many slow speed IK programs is easy to achieve on most variable resistance machines.

Reilly (50) found that variable resistance machines

(VR) produced significantly greater ($P<.01$) mean heart rates (140 beats/min., s.d.=26.9) and significantly greater ($P<.1$) oxygen consumption (2.501/min, s.d.=0.38) than is achieved in conventional circuit training using other types of apparatus. This is probably because circuit stations are closer together on VR machines and less time is required to move from station to another. VR machines are also safer and easier to use than free weights and thus permit the trainer to proceed with less caution than he would when using conventional barbell equipment.

The use of the VR machine as a convenient, relatively maintenance free exercise and testing station for a large number of subjects can not be overlooked. As a training device to emphasize proper progressive resistance principles and correct exercise form to large groups of uninitiated students, it is difficult to surpass.

THE ECCENTRIC FACTOR

The final factor affecting contraction intensity that has come to light with recent research is eccentric contraction or negative work. Eccentric contraction may be a very potent factor in the development of muscular strength. The highest tension that can be developed in the striated muscle occurs during eccentric contraction (2). An eccentric contraction with a muscle lengthening speed of 60% arm length/sec. yielded a maximum pull of 130% of maximal isometric strength in the arm flexor muscle group. Astrand also found that integrated electrical activity and oxygen uptake is much lower for eccentric contractions using the same load but were similar for maximum relative loads.

Komi (31) found that muscle soreness increased as a result of negative work. Miller (41) recorded slightly better 5RM scores as a result of eccentric training when compared with concentric training. Such data suggest that contraction intensity and the stretch effect can be greatly increased if a concentric contraction is paired with a prolonged eccentric contraction, particularly if maximal eccentric strength is taxed; i.e. when assistants are used to raise the weight before it is lowered. Prolonged lowering of loads lifted through the concentric phase may simply be a substitute for more repetitions.

PRINCIPLES OF HIGH INTENSITY WEIGHT TRAINING

As a result of this review, 5 factors were incorporated into the design of the H.I. weight-training program:

1. Slow rates of contraction emphasizing concentric and eccentric work must be maintained .
2. A muscle group must be temporarily stretched before contraction and strict exercise form must be followed.
3. The muscle group must be worked to the point of failure.
4. A Variable Resistance training apparatus should be used.
5. Concentric and eccentric contractions must be maximized in each repetition.

CHAPTER 3

RESEARCH PROCEDURES

SAMPLE - STUDY ONE

Seventy Grade Nine boys from six Physical Education classes at Highland Secondary School who scored in the 12 lowest percentiles on the T.S.C.S. were the subjects for this study. Those subjects who objected to the study or who missed tests or the majority of training sessions were eliminated as were those who quit school. They were replaced by students who scored in the lower half of the total positive score on the T.S.C.S. Subjects were divided into two groups which were equal initially in S.C. scores.

SAMPLE - STUDY TWO

Thirty-nine Years One and Two occupation students at Highland Secondary School were the subjects of this study. Students who were chronically absent or who missed more than 30% of the training sessions were eliminated from this study as well. The remaining group of 20 students were split evenly into 2 groups of 10 subjects each according to a computer printout which equalized the ages and strength scores of each group. There was no significant difference initially in mean strength scores between these groups.

VARIABLES

Muscular Strength - The strength of the major muscles of the body was determined by adding the 1RM scores on the Bench Press, Leg Press, Pulldown, Seated Press, Leg Curl and Arm Curl as revealed by the Starting Poundage reading on the Universal Spartacus weight-training machine. This composite score was regarded as a general indication of overall body strength. In Study Two, Muscular Strength (MS) was determined by the 1RM score on the Leg Press only.

Cardio-Respiratory Endurance (CE) - The ability of the body to supply and utilize oxygen in the tissues, as determined by tests of oxygen consumption. The instrument used to test this variable was Cooper's (11) Twelve Minute Run test. Subjects were told to complete as many laps and partial laps as possible on a 400 metre track within a 12 minute time interval. Subjects were given lap times and encouraged to pass as many pilons as possible before the 12 minutes elapsed.

Anthropometric Measures (AM) - Measures of three body girths were taken: the flexed right upper arm, the flexed right thigh and the expanded chest. Measures were recorded to the nearest tenth of a cm. A composite girth measure was also determined by combining these measures. Measures were taken prior to exercise.

Self-Concept (SC) - A composite of self-preceptions involving the physical, moral-ethical, personal, family and social self in terms of how the subject sees himself in each of these facets, how he accepts what he sees, and how he sees himself behaving or acting in these spheres. Since only the total positive score on the TSCS was used in this study, S.C. may best be regarded as measures of self-esteem.

INDEPENDENT VARIABLES

Interval Circuit Weight-Training (IC) - A system of weight-training where exercises are performed one after another using a one minute work-rest interval for each exercise. Exercises were performed in a fixed order to allow a minimum of 3 minutes of active rest for each of the major muscle groups worked. Six exercises - Bench Press, Leg Press, Pulldown, Seated Press, Leg Curl and Arm Curl - were performed in that order. Subjects selected a weight equivalent to 2/3 of 1RM as their starting poundage and performed 6 repetitions of each exercise on the first circuit, 5 repetitions on the second circuit and 4 repetitions on the third circuit. When the required number of repetitions was achieved, resistance was increased so that in most training sessions, subjects here were also going to failure.

Connor felt that a rest period of 3 minutes should be provided between sets of exercises involving the same muscle group if optimum strength gains were to be realized. By arranging his exercises so that different muscle groups were worked consecutively for a one minute interval, he was able to provide a 3 minute active rest period for each muscle group before it was worked again. Connor found this system to be significantly better ($P < .05$) than the set system in achieving strength gains when work done was the same.

High Intensity Weight-Training - Study One - The Riley Method H.I. - One set of 8-12 repetitions using the same exercises used in the I.C. program. All exercises were performed on the Universal Spartacus apparatus, with a 2 min. exercise-recovery period allowed for each exercise. Subjects trained initially with 2/3 1RM and worked to failure in most exercises. Repetitions involved a 2 sec concentric phase and a 4 sec. eccentric phase done in strict form. Poundages were increased when 12 repetitions were performed.

High Intensity Weight-Training - Study Two - The Mentzer Method HI - Arrangement of exercises so that an isolation exercise preceded a compound exercise for each major muscle group. Six to nine repetitions for each exercise were perrormed using a 4 sec. concentric phase followed by a 4 sec. eccentric phase. No rest between the 2 exercises for each muscle group was allowed so that the point of failure could be achieved. Although this PF could just as easily have been achieved by lowering the resistance and continuing with the same exercise, it was hoped that by doing 2 different exercises, subject boredom would have been alleviated and that the subject might therefore be motivated to work harder than he would if only one exercise were done. The exercises done are listed in Appendix I. When 9 repetitions were performed, more resistance was added.

Teacher Effectiveness - The teacher's level of empathetic understanding, regard for students, congruence and willingness to be known as measured by the Barrett-Lennard Relationship Inventory (BLRI). Rogers (52) felt that teachers who scored highest on the BLRI were generally more effective in getting students to learn to read than were teachers who scored lower on the instrument.

EXPERIMENTAL DESIGN

Study One took nine weeks to complete. One week was used for testing and instruction and seven weeks were devoted to the treatment.

Study Two took ten weeks to complete, and involved testing of leg strength only. Eight weeks were devoted to the treatment in this study.

STATISTICAL DESIGN

Sample means for all variables were computed for both pre-test and post-test measures. Levels of significance of mean differences between pre-test and post-test means were computed within each group. Levels of significance of pre-test and post-test mean differences between groups were also calculated. Levels of significance for t values were set at the .05 level.

STATISTICAL HYPOTHESES

Effect of the Interval Circuit and High Intensity Weight-Training systems on the experimental variables within groups.

Hypothesis 1 : (Strength within groups) No significant difference between pre-test and post-test strength measures within any group will be found.

Hypothesis 2 : (Cardiovascular endurance within groups) No significant difference in pre-test and post-test C.E. measures within any group will be found.

Hypothesis 3 : (Anthropometric measures within groups) No significant difference between pre-test and post-test A.M. within any group will be found.

Hypothesis 4 : (Self-Concept within groups) No significant difference in pre-test and post-test S.C. measures will be found.

Post test comparison of the Interval Circuit and High Intensity weight-training systems on the experimental variables.

Hypothesis 5 : (Strength between treatment groups) No significant difference between post-test strength measures between treatment groups will be found.

Hypothesis 6 : (Cardiovascular endurance between treatment groups) No significant difference between post-test C.E. measures between treatment groups will be found.

Hypothesis 7 : (Anthropometric measures between treatment groups) No significant difference between post test A.M. between treatment groups will be found.

Hypothesis 8 : (Self-Concept between treatment groups) No significant difference between post-test S.C. measures between treatment groups will be found.

Post test comparison of the teacher relationship effect on the experimental variables.

Hypothesis 9 : (Strength between teacher groups) No significant difference between post-test strength measures between teacher groups will be found.

Hypothesis 10 : (C.E. between teacher groups) No significant difference between post-test C.E. measures between teacher groups will be found.

Hypothesis 11 : (A.M. between teacher groups) No significant difference between post-test A.M. between teacher groups will be found.

Hypothesis 12 : (Self-Concept between teacher groups) No significant difference between post test S.C. measures between teacher groups will be found.

CHAPTER 4

ANALYSIS OF DATA

These studies analyzed and compared group treatment reaction to the I.C. and H.I. weight-training systems in four basic areas: strength, cardiovascular endurance, anthropometric measures and self-concept. The strength analysis in Study One was based on the results obtained from six 1RM tests administered to both groups. The strength analysis in Study Two was based on the results obtained from 1RM tests on Leg Press only. This method of testing was desirable in this study because of the many differences between the I.C. and H.I. programs involved. (See Appendices A and C) Since the number of leg exercise repetitions done in each program were equivalent (see Table 14), a better estimate of the efficacy of each program could be secured by concentrating on the 1RM Leg Press test only.

The cardiovascular endurance analysis was based on the results achieved on Cooper's Twelve Minute Run Test. Anthropometric analysis was based on the results of three girth measures and Self-Concept was based on the Total Positive Scores secured on the Tennessee Self-concept Scale.

It is the purpose of this section to report the effect of the Interval Circuit and High Intensity weight-training systems both within and between groups for each of the variables.

A series of t tests were run on pretest means between groups for all variables in the study. Study One revealed no significant initial differences between the I.C. and the H.I. groups in S.C., C.E. and girth measurements. There was however a significant initial difference in strength between these two groups. The H.I. group had a significantly higher ($P < .01$) mean strength composite score than did the I.C. group. Pretest strength means in Study Two however were not significantly different so that a better comparison of the effects of the two treatments on strength development could be made.

EFFECT OF THE INTERVAL CIRCUIT AND HIGH INTENSITY WEIGHT-TRAINING SYSTEMS ON THE EXPERIMENTAL VARIABLES WITHIN GROUPS.

Hypothesis 1 : Strength Within Groups

It was stated in Hypothesis 1 that no significant differences between pretest and post test strength measures within either group would be found. Data collected and analyzed to test this hypothesis are presented in Tables 1 and 2 . In each experimental group except the I.C. group in Study Two and one of the I.C. groups in Study One, significant strength gains were found. Since all groups exposed to the H.I. program in both studies made significant strength gains however, we can reject the null hypothesis for the strength variable in the H.I. group.

TABLE 1

STUDY ONE

Comparison of Pre Test and Post Test Mean Strength Scores (Composite)
Within the Interval Circuit and Within the High Intensity Groups (in pounds)

Group	Class	N	Pretest		Post Test		$\bar{X}$ Gain	% Gain	t test score
			$\bar{X}$	SD	$\bar{X}$	SD			
Interval Circuit	151-04 control	15	716,3	125.33	805.6	136.85	89.3	12.46%	1.863
	151-04	13	573.84	92.17	735.0	104.04	161.16	28.08%	4.18 ****
	151-05	10	617.0	122.27	763.0	184.54	146.0	23.66%	2.08
	all experiment. groups	23	592.60	106.12	747.2	137.74	154.57	26.08%	2.97 ****
High Intensity	151-03 control	12	585.8	78.64	677.9	74.31	92.08	15.71%	2.886 ****
	151-03	10	634.5	70.25	729.0	64.88	94.5	14.89%	3.124 ****
	111	10	700.0	102.17	809.5	88.2	109.5	15.64%	2.56 **
	all experiment. groups	20	667.25	87.67	769.25	77.42	102.0	15.28%	3.465 ****

* significant at .05 level

TABLE 2

STUDY TWO

Comparison of Pretest and Post Test Mean Leg Strength Scores Within High Intensity and Interval Circuit Groups. (Pounds)

Group	N	Pretest		Post Test		X Gain	% Gain	t test score
		X	S.D.	X	S.D.			
High Intensity	10	284.0	52.11	358.5	81.07	74.5	26.23%	2.44 *
Interval Circuit	10	315.0	94.42	396.0	91.64	81.0	25.74%	1.94

* significant at .05 level

Hypothesis 2 : Cardiovascular Endurance Within Groups

It was stated in Hypothesis 2 that no significant difference between pretest and post test C.E. measures within either group would be found. Data collected and analyzed to test this hypothesis are presented in Table 3. No significant improvement in CE was indicated in either training group. Thus the null hypothesis was accepted for both groups although the I.C. group did make a 5.65% gain in 12 Minute Run scores, a gain that was significant at the 0.1 level of confidence.

Hypothesis 3 : Anthropometric Measures Within Groups

It was stated in Hypothesis 3 that no significant difference between pretest and post test anthropometric measures within either group would be found. Data collected and analyzed to test this hypothesis are presented in Table 4. Although a 3.13% gain was made by the I.C. group, and a 3.47% gain was made by the H.I. group, none of these gains were statistically significant. Thus the null hypothesis was maintained for both groups.

Hypothesis 4 : Self-Concept Within Groups

It was stated in Hypothesis 4 that no significant difference between pretest and post test self-concept scores within either group would be found. Data collected and analyzed to test this hypothesis are presented in Table 5. A 7.7% gain in self-concept score in the I.C. group in Study One was recorded. This gain is significant at the .05 level of confidence.

Table 3

STUDY ONE

Comparison of Pretest and Post Test Mean 12 Minute Run scores Within the Interval Circuit and Within the High Intensity Groups. (in Meters)

Group	Class	N	Pretest		Post Test		$\overline{X}$ Gain	% Gain	t test score
			$\overline{X}$	SD	$\overline{X}$	SD			
Interval Circuit	151-04 control	6	2425.0	415.63	2625.0	412.0	200.0	8.24%	0.837
	151-04	12	2283.3	323.56	2520.83	381.65	237.53	10.40%	1.645 #
	151-05	9	2261.0	244.6	2244.4	274.36	-16.6	-0.73%	-0.135
	all experiment. groups	21	2273.8	292.95	2402.38	340.62	128.58	5.65%	1.345 #
High Intensity	151-03 control	10	2520.0	266.87	2545.0	319.24	25.0	0.79%	0.189
	151-03	10	2485.0	179.58	2565.0	241.50	80.0	3.22%	0.84
	111	10	2370.0	301.1	2355.0	313.09	-15.0	-0.63%	-0.109
	all experiment. groups	20	2427.5	247.90	2460.0	279.63	32.5	1.34%	0.282

Significant at 0.1 level of confidence

Table 4

STUDY ONE

Comparison of Pretest and Post Test Mean Composite Girth Measurements Within the Interval Circuit and Within the High Intensity Groups (in Centimeters)

Group	Class	N	Pretest		Post Test		$\overline{X}$ Gain	% Gain	t test score
			$\overline{X}$	SD	$\overline{X}$	SD			
Interval Circuit	151-04 control	15	164.62	15.05	168.49	15.05	3.87	2.35%	0.368
	151-04	13	164.9	26.44	171.53	26.44	6.63	4.02%	0.639
	151-05	10	160.5	23.37	163.6	24.25	3.1	1.93%	0.291
	all experiment groups	23	162.98	25.17	168.07	25.53	5.09	3.13%	0.489
High Intensity	151-03 control	11	163.38	10.37	167.1	7.97	3.72	2.27%	0.943
	151-03	9	164.35	10.86	170.35	11.35	6.0	3.65%	1.14
	111	8	164.96	18.64	170.36	15.45	5.4	3.27%	0.630
	all experiment groups	17	164.64	15.00	170.36	13.42	5.72	3.47%	1.21

Table 5

STUDY ONE

Comparison of Pre Test and Post Test Mean Tennessee Self Concept Scores Within the Interval Circuit and Within the High Intensity Groups.

Group	Class	N	Pretest		Post Test		$\overline{X}$ Gain	% Gain	t Test score
			$\overline{X}$	SD	$\overline{X}$	SD			
Interval Circuit	151-04 control	12	343.75	28.56	359.0	25.66	15.25	4.4%	1.375
	151-04	12	307.5	20.04	334.75	24.72	27.25	8.86%	2.96 ****
	151-05	10	303.9	31.51	323.0	32.11	19.1	6.28%	1.34
	all experiment. groups	22	305.86	25.84	329.41	28.28	23.55	7.70%	2.08 *
High Intensity	151-03 control	9	366.6	16.09	376.7	19.04	10.1	2.75%	1.215
	151-03	11	311.8	31.04	313.5	31.29	1.7	0.54%	0.127
	111	10	310.9	15.32	312.9	21.48	2.0	0.64%	0.239
	all experiment. groups	21	311.38	24.87	313.24	27.09	1.86	0.59%	0.168

** Significant at .025 level

**** " " .005 "

No significant gain in self-concept occurred in the H.I. group. Thus we can reject the null hypothesis for self-concept in the I.C. group.

Comparison of the Interval Circuit and High Intensity Weight Training Systems on the Experimental Variables.

Hypothesis 5 : Strength Between Groups.

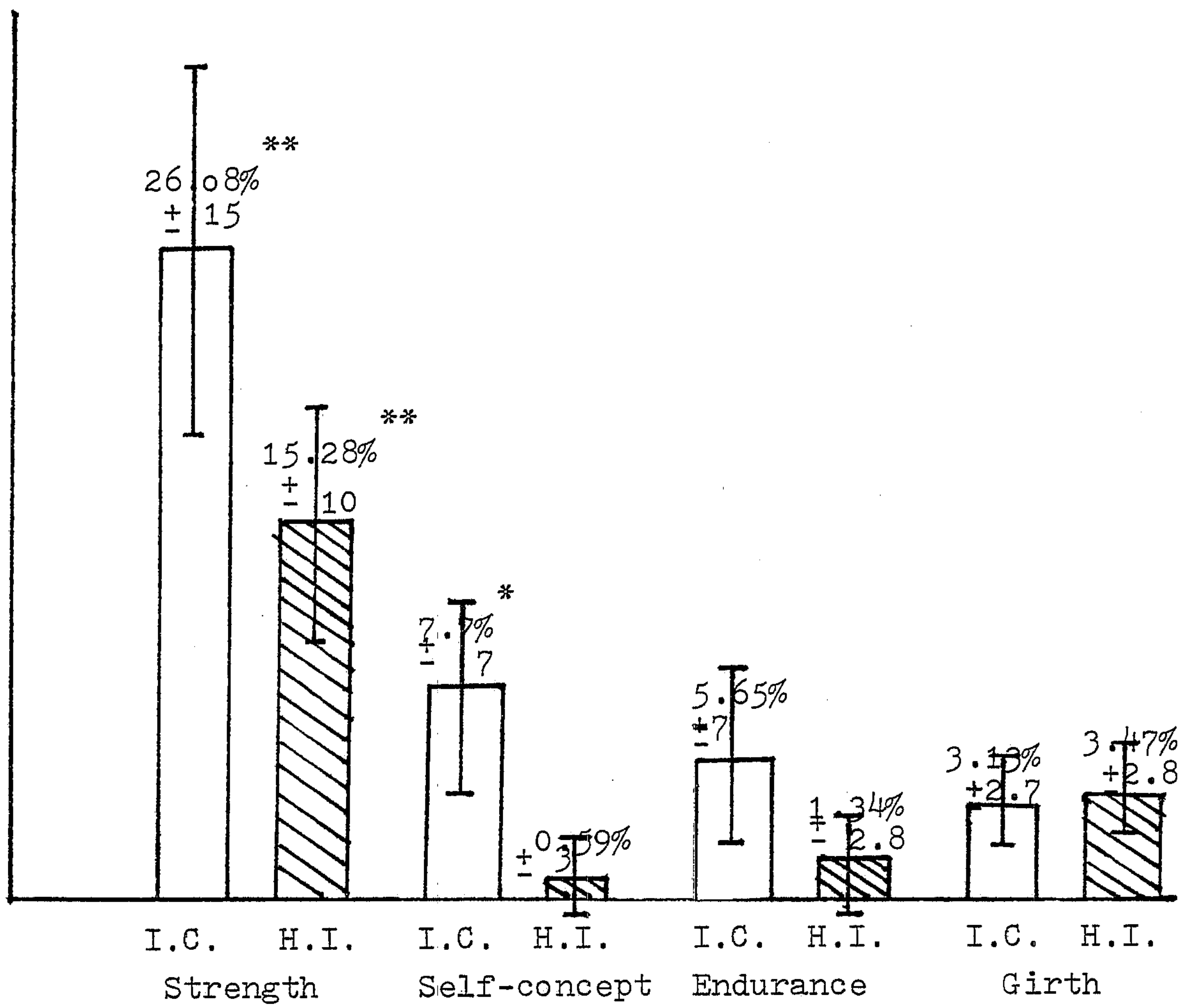
It was stated in Hypothesis 5 that no significant difference between post test strength measures between groups would be found. Data collected and analyzed to test this hypothesis are presented in Figure 1 and Table 6. Since the Study One groups were unequal in mean strength scores to begin with, an analysis of the percentage gains is presented in Figure 1. This figure suggests that the I.C. produced larger gains in strength and most other variables than did the H.I. but such results are not statistically significant. Table 6 reveals that no significant difference between the two treatment groups in Study Two occurs. Hence the null hypothesis must be accepted.

Hypothesis 6 : Cardiovascular Endurance Between Groups.

It was stated in Hypothesis 6 that no significant difference between post test C.E. measures would be found. Data collected and analyzed to test this hypothesis are presented in Table 7. No significant difference between post Test 12 Minute Run scores could be found. Thus the null hypothesis was accepted.

FIGURE 1

Study One Comparison of Percentage Gains Between Interval Circuit and High Intensity Groups on Experimental Variables



* Significant at .05 level

** Significant at .005 level

Interval Circuit

High Intensity

TABLE 6

STUDY TWO

Comparison of Mean Pretest and Post Test Leg Strength Scores Between Groups (Pounds)

N	Group	Pretest				Post Test			
		X	S.D.	X Diff.	t score	X	S.D.	X Diff.	t Score
10	High Intensity	284.0	52.11			358.5	81.07		
10	Interval Circuit	315.0	94.42	31.0	0.909	396.0	91.64	37.5	0.969

Table 7

STUDY ONE

Comparison of Mean Pretest and Post Test 12 Minute Run Scores

Between Groups (in Meters)

N	Group	Pretest				Post Test			
		$\overline{X}$	SD	$\overline{X}$ diff.	t score	$\overline{X}$	SD	$\overline{X}$ diff.	t score
21	Interval Circuit	2273.8	292.95			2402.38	340.62		
20	High Intensity	2427.5	247.90	153.7	1.85	2460.0	279.63	57.62	0.606

* Significant beyond the .05 level of confidence

Hypothesis 7 : Anthropometric Measures Between Groups.

It was stated in Hypothesis 7 that no significant difference in post test A.M. between groups would be found. Data collected and analyzed to test this hypothesis are presented in Table 8. No significant differences between post test A.M. were found between the I.C.and the H.I. groups. Thus the null hypothesis was retained.

Hypothesis 8 : Self-concept Between Groups.

It was stated in Hypothesis 8 that no significant difference in post test self-concept scores between groups would be found. Data collected and analyzed to test this hypothesis are presented in Table 9. A significant difference in self-concept scores occurred between the two groups in the post test. The I.C. program is superior to the H.I.program in the development of self-concept. Thus the null hypothesis is rejected.

Post Test Comparison of the Teacher Relationship Effect on the Experimental Variables.

Hypotheses 9 - 12 : Strength, Cardiovascular Endurance, Anthropometric Measures and Self-Concept Between Teacher Groups.

Hypotheses 9 -12 stated that no significant difference between post test measures between teacher groups would be found. Data collected and analyzed to test these

Table 8

STUDY ONE

Comparison of Mean Pretest and Post Test Composite Girth Measurements Between Groups (Centimeters)

N	Group	Pretest				Post Test			
		$\overline{X}$	SD	$\overline{X}$ diff.	t score	$\overline{X}$	SD	$\overline{X}$ diff.	t score
23	Interval Circuit	162.98	25.17			168.07	25.53		
17	High Intensity	164.64	15.00	1.66	0.247	170.36	13.42	2.29	0.344

Table 9

STUDY ONE

Comparison of Mean Pre Test and Post Test Self Concept Scores

Between Groups

N	Group	Pre Test				Post Test			
		X	SD	X diff	t score	X	SD	X diff	t score
22	Interval Circuit	305.86	25.84			329.41	28.28		
21	High Intensity	311.38	24.87	5.52	0.541	313.24	27.09	16.17	1.96

hypotheses are presented in Tables 10 - 13. No significant differences between post test strength, endurance, girth and self- concept measures were found between Teacher A's group and those of Teacher B. Teacher A's group scored consistently higher on all variables but such differences did not reach the level of significance established for this study. (Figure 2)

TABLE 10

STUDY ONE

Comparison of Mean Pretest and Post Test Strength Scores Between Teacher Groups

N	Teacher Group	Pretest				Post Test			
		X	S.D.	X Diff.	t score	X	S.D.	X Diff.	t Score
13	151-04 A	573.84	92.17			735	104.04		
10	151-05 B	617.0	122.27	43.16	0.96	763	184.54	28.0	0.46

TABLE 11
STUDY ONE

Comparison of Mean Pretest and Post Test Self-Concept Scores Between Teacher Groups

N	Group Teach.	Pretest				Post Test			
		X	S.D.	X Diff.	t score	X	S.D.	X Diff.	t score
12	151-04 A	307.5	20.04			334.75	24.72		
10	151-05 B	303.9	31.51	3.6	0.325	323.0	32.11	11.75	0.97

TABLE 12

STUDY ONE

Comparison of Mean Pretest and Post Test Twelve Minute Run Scores between Teacher Groups

N	Group Teach		Pretest				Post Test			
			XX	S.D.	X Diff.	t score	X	S.D.	X Diff.	t score
12	151-04	A	2283.3	323.56			2520.8	381.65		
9	151-05	B	2261.0	244.6	22.3	.171	2244.4	274.36	276.4	1.84

TABLE 13

STUDY ONE

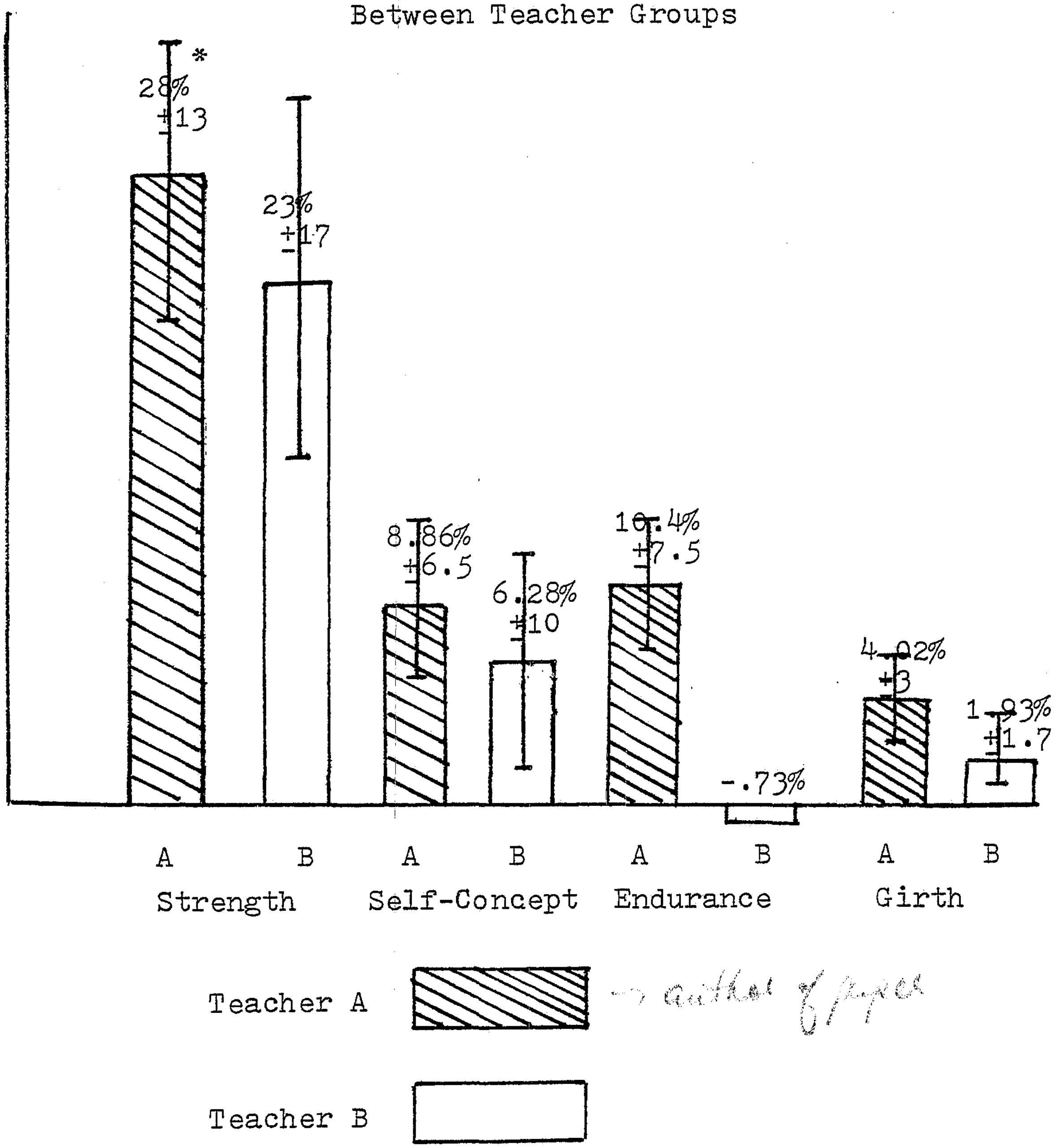
Comparison of Mean Pretest and Post Test Composite Girth Measurements
Between Teacher Groups

N	Group Teach	Pretest				Post Test			
		X	S.D.	X Diff.	t score	X	S.D.	X Diff	t score
13	151-04 A	164.9	26.44			171.53	26.44		
10	151-05 B	160.5	23.37	4.4	0.44	163.6	24.35	7.93	0.80

FIGURE 2

STUDY ONE

Percentage Gains in Experimental Variables
Between Teacher Groups



* Significant at .05 level of confidence.

CHAPTER 5

SUMMARY, CONCLUSIONS, DISCUSSION AND RECOMMENDATIONS

SUMMARY

This study was conducted to determine the effects of High Intensity weight training systems on high school boys in the area of muscular strength, cardiovascular endurance, anthropometric measures and self-concept. Two High Intensity methods of training were compared with the Interval Circuit method of training. In the first study, six basic weight-training exercises were utilized in both the Interval Circuit and High Intensity programs. The Interval Circuit program utilized three sets for each exercise with a maximum of 15 total repetitions for the three sets. The High Intensity system utilized one set of a maximum of 12 repetitions in each exercise. All exercises were performed on the Universal Spartacus Apparatus.

The Interval Circuit was completed in approximately 18 minutes whereas the High Intensity program was completed in 12 minutes. In Study Two, the Interval Circuit program remained the same as that used in Study ~~Two~~ One. but the High Intensity program consisted of two exercises for each muscle group, done one after the other so that an isolation exercise was followed by a compound exercise. The average total number of repetitions for the I.C. was 15 while the average number of repetitions performed in the H.I. was 14.

In Study One, a one-minute work-rest interval was employed for each exercise in the I.C. program. Exercise began at the start of the one minute work-rest interval and continued until the required number of repetitions were performed or until the subject could not perform another repetition. The subject then rested for the remainder of the minute. The H.I. program in Study One involved a two-minute work-rest interval but since only one set per exercise was performed, this program was completed in 12 minutes rather than 18.

The only difference between Study One and Study Two was in the exercise prescription for the H.I. group. Here two sets of 6 - 9 repetitions were performed rather than one set of 8 - 12 repetitions. These two sets consisted of one isolation exercise followed by one compound exercise.

In both High Intensity programs, subjects employed a four second concentric contraction followed by a four second eccentric contraction. Emphasis on performing the exercises in strict form resulted in a complete stretch of the muscle as it went through the extension and flexion stage. Exercises were performed to total failure and subjects concentrated on the muscle groups being worked. In Study Two, subjects first utilized an isolation exercise or one that was designed primarily to work only that particular muscle group. The isolation exercise was then followed immediately by a compound exercise which employed the same muscle group as well as other muscle groups that assisted with the action being performed. This exercise was also performed to the point of failure sometimes with assistance through the concentric phase. The objective was to force the muscle to employ motor units that would not normally be recruited during mild to moderate forms of exercise.

Seventy Grade Nine boys from six Physical Education classes at Highland Secondary School who scored in the twelve lowest percentile ranges on the Tennessee Self-Concept Scale composed the sample for Study One. Twenty Years One and Two Occupation students at Highland Secondary School composed the sample for the second study. These were all the boys who were in regular attendance in that program. These subjects were randomly assigned via a computer printout to two groups of equal strength, each containing ten subjects. All groups exercised regularly every second school day for a period of nine weeks.

Dependent variables present in this study were muscular strength, cardiovascular endurance, muscle girth and self-concept. These four variables were analyzed using t test data collected prior to and in the week immediately following the nine week program as follows:

1. Six muscle groups primarily affected by the exercises utilized were tested for strength using the 1RM test on the Universal Spartacus Apparatus. In Study One, a strength composite variable was computed by summing the scores for the six

tests. The six tests selected measured elbow flexion, knee flexion, knee extension, shoulder adduction, shoulder abduction and shoulder horizontal flexion strength. In Study Two, only knee extension strength was measured.

2. Cardiovascular endurance was measured by way of Cooper's Twelve Minute Run Test and recorded in meters.

3. Anthropometric measures included flexed girth measures of the body areas primarily affected by the exercises: arm girth, chest girth, and thigh firth. A girth composite variable was computed by summing the girth measures. Girth measurements were taken by the author at the point of greatest circumference and recorded in centimeters.

4. Self-concept was measured by using the Tennessee Self-Concept Scale. This scale measures a subject's assessment of his physical, moral-ethical , personal, family and social self in terms of how he sees himself being and behaving and also the extent to which he accepts what he sees.

Sample means and variances for all measures were computed for both pre-test and post test scores. A series of t tests for both correlated and independent samples were computed to analyze differences both within and between the variables examined. Level of significance for t values was set at the .05 level.

SUMMARY OF FINDINGS

1. Both the Interval Circuit and the High Intensity Groups in Study One gained significantly in strength from pre-test to post test.

2. The Interval Circuit group in Study One gained significantly in Self-concept.

3. In Study Two, the High Intensity group improved significantly in strength from pre-test to post test. No significant strength gain was recorded for the Interval Circuit group.

CONCLUSIONS

Within the limitations of the samples and procedures employed in this study, the following conclusions seem justified.

1. The High Intensity method of strength-training is at least as effective as the Interval Circuit method in producing consistent increases in strength. In both studies, the High Intensity program yielded significant strength gains. Although the Interval Circuit program produced a significant 26% strength gain in Study One, it did not produce a significant strength gain in Study Two although the gain was almost as large (25.74% in I.C., 26.23% in H.I.) as that secured in the High Intensity program.

2. Neither the Interval Circuit nor the High Intensity program will produce significant gains in cardio-respiratory endurance as measured by Cooper's Twelve Minute Run Test.

3. Neither the Interval Circuit nor the High Intensity programs will produce significant gains in anthropometric measures within a nine week period.

4. The Interval Circuit will produce significant gains in students' self-concept as measured by the TSCS.

5. The High Intensity system of training will produce significant gains in student strength that are equal to those developed using the Interval Circuit system, especially if the Mentzer prescription is adhered to.

6. Considering that the High Intensity type of training described requires two-thirds of the time required to complete the Interval Circuit, and that it does produce significant strength gains, the High Intensity program can be a valuable training technique for the Physical Educator to improve strength when limited time is a factor. A similar time reduction in the Interval Circuit would violate the 3 set prescription and the 3 minute rest interval that Connor felt was necessary to produce optimum strength gains.

DISCUSSION

The Anthropometric and Cardiovascular Variables

Although Connor (10) secured significant gains in these variables using the I.C. program, no significant increase in these variables occurred in the present study. It may be that a more frequent exercise prescription or more weeks of training is required before increases in muscle size can be properly measured or discerned. Those researchers (10,36,46) who reported significant increases in muscle size all had their subjects train on a three day per week basis whereas subjects in the present study only worked out every second school day.

Connor's instrument for measuring gains in cardiovascular endurance was the Ohio State University Step Test. Whether improvements on this test are entirely a reflection of increased cardiovascular endurance is highly questionable. The increased quadriceps strength resulting from the Interval Circuit program may have been the major reason for Connor's subjects' significant improvements in step test scores.

Strength Gains

Although Connor demonstrated significant strength gains as a result of the I,C. program, such gains were not consistently demonstrated in the present studies. The I.C. program in Study One revealed a significant 26.08% strength gain but the 25.74% gain in Study Two did not reach the level of significance established for this study. Since most authorities (5,10,44,46)recommend a 3 day per week training schedule, it is possible that the 2-3 days per week schedule used in the present study was not intense enough to bring about the desired strength gains.

The fact that High Intensity programs consistently produced significant increases in both studies suggests that some intensity factor is operative in this program that is not consistently present in the Interval Circuit program. One of the I.C. groups in Study One and all of the I.C. group in Study Two failed to make significant strength gains. While it is conceivable that this failure of the I.C. program may be due to sampling problems in Study One, it is doubtful that sample error could have caused this failure in Study Two because here true random procedures were followed in the selection of training groups.

In Study Two, an attempt to equate treatments in terms of repetitions per body part and in Repetitions x Pounds was made. (Table 14) As can be seen in Table 14, the number of repetitions performed in each program was approximately equal. Subjects in the I.C. program performed an average of 14.7 leg exercise repetitions; those involved in the H.I. program performed an average of 13.8 leg exercise repetitions. (Column 1).

In Column 2, a Repetitions x Pounds figure was determined by multiplying the total number of repetitions performed by the weight lifted per subject. The average Repetition Pounds (RP) performed per training session by subjects in the I.C.program was 3760.5 almost twice that performed by subjects in the H.I. program. (1956.6 RP)

IC Ss performed 3 sets of 4-6 reps on leg press [illegible] 6 min work-rest interval between sets – weight lifted in extensions is less than press ∴ less work appeared to be done.
HI - Ss performed 1 set of leg extensions followed by 1 set of leg press – 6-9 reps

*

TABLE 14

STUDY TWO

Comparison of Leg Work Done Using the High Intensity and the Interval Circuit Programs.

115 × 1956.6

	1. Average Reps./ Training Session	2. Average Rep.-lbs./ Training Session	3. Total Subject-Training Sessions	4. Total Reps. Perform.	5. Total Rep.-lbs.	6. Average Time/ Rep.	7. Intensity Reps. x Pounds x Time
HIGH INTENSITY	13.8	1956.6	115	1590	225010	8 secs.	15653
INTERVAL CIRCUIT	14.7	3760.5	103	1523	387340	2 secs.	7521

8 × 1956.6

total # of reps × [illegible] lifted ∴ IC avg. did almost 2 × wt

12 more training sessions

HI SS did 67 more total reps than IC

103 × 3760.5 ∴ the IC [illegible]

[illegible] contraction time

2 × 3760.5

Although the H.I. group performed a total of 12 more training sessions and 67 more total repetitions than did the I.C. group (Columns 3 &4), the I.C. group still performed more work - a total of 162330 more RP's - than did the H.I. group. (Column 5)

It would appear obvious, therefore, that the intensity factor involved in the H.I. program is not related to the amount of weight lifted or the average repetitions or RP's performed per training session. Subjects involved in the I.C. program performed 3 sets of 4-6 repetitions on the leg press with a 6 minute work-rest interval between sets. Subjects involved in the H.I. program performed only 1 set of leg extensions, followed immediately by 1 set of leg presses, each done 6-9 repetitions. Since the weight handled in the leg extension exercise was considerably less than that handled in the leg press and since fewer total repetitions were performed, less work appeared to be done here than was done in the I.C. program.

Since both programs produced approximately equal strength gains, Connor's 3 set prescription may not be necessary if optimum strength gains are desired. If 2 sets of H.I. training will produce this training effect, perhaps 2 sets of I.C. training might also be as effective. It appears obvious that 13.8 H.I. repetitions are at least as effective as 14.7 I.C. contractions even though only 2 sets were performed. Since there is no 3 minute rest interval between the H.I. sets, this prescription may also be questionable.

At any rate, the intensity factor that must have produced the significant strength gain had to be related to the principles of H.I. weight-training described on Page 41. Since Mentzer's H.I. program secured an 11% greater gain in strength than Riley's program did, one must assume that students are better motivated by a variety of exercises than they would be when required to perform one exercise for 12 repetitions. Thus the use of isolation and compound exercises and the reduced number of repetitions might be the best procedure to follow if one wishes to optimize going to the point of failure.

Column 7 of Table 14 indicates that contraction time may be the intensity factor in H.I. exercise, particularly if it is multiplied by the RP figure. This intensity figure for the H.I. group is more than double that of the I.C. group even though the total time required to complete the H.I. training is 2/3 that required to complete Connor's I.C.

<u>The Process of Strength Development</u>.

The results of this study indicate that only two of the author's original research hypotheses have been clearly supported; i.e. that weight-training will result in significant gains in strength and in self-concept. With these findings in mind, the author would like to address himself to these two variables in hopes of adding some insight into the reasons for these gains. The all important question as far as this author is concerned is simply this : Why should the High Intensity weight-training system produce consistent strength gains when the Interval Circuit program which was touted as being superior to the set system was inconsistent in developing significant strength gains?

A close examination of Connor's I.C. system reveals a number of questionable practices. His insistence on a 3 minute rest interval so that the muscle could recover lost strength may actually be counterproductive if maximum mobilization of motor units is to be achieved. Since 6 repetitions was the maximum number of repetitions that was employed in any one set, it is doubtful if a true point of failure was achieved particularly in the first two sets. Because subjects were confined to a one minute work-rest interval, exercise form tended to be minimized. The sustained tension common in the H.I. program was not as evident in the I.C. group. I.C. subjects tended to use fast, explosive types of training where initial thrusts were allowed to carry the weight through the concentric phase at a fairly rapid rate and where the eccentric phase was minimized by allowing the weight to drop in a fast, virtually uncontrolled fashion.

Milner-Brown (43) has proved rather conclusively that weight-lifters and others who are trained to exert large brief forces at work show a significant degree of motor unit synchronization over inactive controls. After six weeks of six daily maximal contractions lasting 5 - 10 seconds, the impulses from two or more units coincided in time more frequently than expected for independent random processes.

Such an increase in motor unit synchronization suggests that supraspinal connections from the motor cortex directly to spinal motoneurons may be enhanced as a result of training to the point that they produce this synchronization during steady voluntary contraction.

Sale's (53) study of motoneuron excitability tends to support this idea. He stated that a reduction in motoneuron excitability during maximal voluntary contraction (as a result of immobility) would indicate reduced recruitment and firing rate of motoneurons. Both of these changes would reduce the force of contraction. Sale suggested that disuse impaired the ability of descending motor pathways to excite the spinal motoneurons and that perhaps disuse makes the motor end plate more susceptible to failure during high frequency stimulation.

One would presume, therefore, that if the decrease in voluntary strength that results from immobilization-induced disuse is caused in part by adaptive changes in the nervous system, then the increase in voluntary strength that results from High Intensity weight-training is also caused in part by adaptive changes in the nervous system. Perhaps an increase in voluntary strength is partly due to an improvement of the ability of descending motor pathways to excite the spinal motoneurons. It is also possible that programs like High Intensity weight-training improve the motor end plate's ability to adapt to high frequency stimulation.

Hayes (21) maintains that in addition to the adaptive changes suggested by Sale, there is also an increase in motor unit synchronization similar to the process described by Milner-Brown (43) as a result of weight-training. Hayes felt that this increase in motor unit recruitment and firing frequency was the result of Renshaw Cell feedback. He also suggests that such effects of training are cumulative and that some process occurring during each bout of exercise constitutes the necessary stimulus that on repetition becomes transformed into a residual training effect. He suggests that the increased gain of the stretch servo mechanism associated with High Intensity contractions and fatigue constitutes the necessary training stimulus.

Self-Concept Enhancement

The gain in self-concept evidenced by the Interval Circuit group is surprising since no similar gain was made by the High Intensity weight-training group. Although the H.I. group in Study One did make a significant 15.28% strength gain, perhaps such a gain was not large enough to significantly affect the ego of these subjects. Schmedinghoff (48) felt that self-concept improvement would only occur if the activity in which the child participated was of a very intense ego-involving nature. The strength gain secured by the I.C. group was 26.08%, almost twice that secured by the H.I. group. The training program of the I.C. group in Study One was also much more severe involving a total of 18 sets while that of the H.I. group involved only 6 sets and less resistance in most exercises. Since the self-concept measuring instrument that was used assessed the student's moral-ethical, personal, family and social self as well as his conception of his physical self, a myriad of forces could be at work to develop this complex variable.

Teacher-student relationship as measured by the BLRI does not appear to be a significant factor in the development of this variable, although there is very little evidence here to support this claim. A random sample of one class taught by each teacher revealed that Teacher A scored a mean score of 5.33 on the BLRI whereas Teacher B had a mean score of 17.6. Since the inventory is designed to measure a teacher's level of empathetic understanding, congruence, willingness to be known, and the unconditionality of his regard for his students, Teacher B would appear to be superior to Teacher A in these qualities; however, Teacher A's class scored consistently higher on all variables than did Teacher B's class. (Figure 1).

Although most of these gains did not reach the level of significance established for the study, Teacher A's class's 10.4% gain in endurance was significant at the 0.1 level of confidence and his group's 8.56% gain in self-concept was significant at the .005 level of confidence.

Thus it appears obvious to this author that much of the increased performance in Teacher A's class was due to the fact that as the author of this study, he probably made greater demands of his class than did Teacher B who had no vested interest in the study. Although the discrepancy in student performance in the two classes mentioned was not statistically significant, it suggests that other factors besides student-teacher relationships as measured by the BLRI are at work to determine student achievement in the average classroom. Such an inventory may be excellent for determining the empathetic qualities described and may be the best tool to use when measuring the counsellor's or therapist's competence. It may even be one measure of excellence in teaching but the role of the teacher and that of the therapist are genuinely different in at least one respect. Teachers normally do not regard students in an unconditional manner. If they did, little progress would be made in most classrooms. The teacher's role is to care not to coddle. To accept a sub-par performance from a student who is capable of much more is to negate the teacher's role as a facilitator of learning. Most recent research (12, 47) indicates that the majority of students not only expect their teachers to keep order in the classroom but also expect that their teachers will make them learn.

Such student expectations certainly would be more likely realized if the teacher were an empathetic, congruent and understanding person who was willing to be known. A random sampling of teachers deemed to be superior by their peers revealed average BLRI scores as high as 72; however, human nature being what it is, teachers must also use some degree of coercion if results are to be forthcoming from their classes. Perhaps a good teacher-student relationship was best described by Pederson (47) when he described the influence that Miss A had over her first grade children:

> She kept control by sheer force of personality and by her obvious affection for her children. There was no way that the pupil was not going to read by the end of Grade One. She left her pupils with a profound sense of the importance of school and how one should stick to it. She gave extra hours to children who were slow learners When children forgot their lunches, she would give them some of her own. She could remember each former pupil by name even after an interval of twenty years. How did she teach? With a lot of love.

Such sterling qualities may or may not be assessed by the BLRI. The important thing to note is that Miss A's classes had a level of intensity that may not be common in too many classes today. Such a level of intensity may be the key to the learning process and may be one explanation for the differences in self-concept enhancement in the two groups in Study One. It is conceivable that this researcher's bias towards the Interval Circuit in Study One made that program more important to students in those classes. Perhaps students, being as perceptive as they are, can determine the degree of commitment that a teacher has to a particular program or approach. It is possible therefore, that the more convinced the teacher is that something is happening in his class, the more likely it is that some positive learning will take place.

RECOMMENDATIONS

On the basis of this investigation, the following recommendations are presented:

1. Further study into the effects of slow vs. fast types of training should be conducted.

2. Further studies to investigate the effects of training that develop high levels of muscle tension should be made.

3. Further psychological studies of the effects of teacher-student relationships should be conducted, particularly in the area of self-concept.

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Personal Weight Training Chart

HIGH INTENSITY

Name Age Class

			1	2	3	4	5	6	7	8	9	10	11	12	13
LEGS	Leg Extension	Wt.													
		Reps													
	Leg Press	Wt.													
		Reps													
ack	Straight Arm Pulldown	Wt.													
		Reps													
	Pulley Rowing	Wt.													
		Reps													
Chest	Lying Incline Laterals	Wt.													
		Reps													
	Bench Press	Wt.													
		Reps													
Shoulders	Standing Laterals	Wt.													
		Reps													
	Press Behind Neck	Wt.													
		Reps													
Triceps	Triceps Pressdown	Wt.													
		Reps													
	Bench Dips	Wt.													
		Reps													
iceps	Curls	Wt.													
		Reps													
	Pulley Pulldowns	Wt.													
		Reps													

INTERVAL CIRCUIT

Personal Weight training Chart

Name ____________________ Age ________

Exercise	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
	RW	RW	RW	RW	RW	RW	RW	RW	RW	RW	RW	RW	RW	RW	RW	RW	RW	RW	RW	RW
BENCH PRESS																				
LEG PRESS																				
PULLDOWN																				
PRESS																				
LEG CURL																				
ARM CURL																				