THE RELATIVE EFFECTIVENESS OF INTERVAL CIRCUIT TRAINING COMPARED WITH THREE OTHER METHODS OF FITNESS TRAINING IN A SCHOOL PHYSICAL EDUCATION PROGRAMME

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ABSTRACT

Much controversy exists regarding the most efficient means of applying methods of progressive resistance work in training routines. The contrasting principles of isometric and isotonic exercise have added further confusion to the area.

This study combines different forms of endurance and dynamic strength training in an easily administered form which can be used in a school physical education programme. It compares this method, called here, Interval Circuit Training, with three other types of training to determine which of these methods could be used best in a school.

Four groups of fourteen to sixteen year old boys were matched initially on the basis of their scores on three indices; The Harvard Step Test Index, Larson's Strength Index, McCloys Classification Index. The first two of these indices namely endurance and strength were combined to give a Total Fitness Factor. The initial scores of the boys on each of these same tests also gave measures of what have been called The Endurance Factor and The Dynamic Strength Factor respectively.

The boys took park in four different training programmes. One group did Interval Circuit Training emphasising endurance and strength training, one group conventional Circuit Training combined with endurance running, another group conventional Circuit Training followed by games activity and the final group had a total **Activity** programme. They took part in the different training methods once every eight days for a period of two months by which time eight training sessions had been completed. During the rest of their weekly programme all the groups followed a similar programme of athletics and

gymnastics and there was no specific weight training or endurance running performed by any of the groups during this time.

After two months the groups were re-tested and the respective fitness indices calculated. The differences of mean gains occurring between the groups from test to re-test were compared.

The Interval Circuit Training Group showed gains in total fitness over the Circuit Training Activity group and the Games Activity group at the level of significance chosen (0.1). Also no significant gains were made by any of the other groups over each other in any of the factors tested at the 10 per cent level of confidence.

Gains in the scores were made from test to re-test by all the groups on all the factors. The largest gains were made by the Interval Circuit Training group and these gains were particularly evident in the strength factor.

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CHAPTER I

STATEMENT OF THE PROBLEM

Circuit training has assumed an important place in the physical education programmes of schools and colleges. Several adaptations and experiments have been made with the general method.

The method as originally outlined by Morgan and Adamson (1) consists of several progressive resistance exercises in sequence called a circuit. To attempt a circuit an individual first determines the maximum repetitions of an exercise which he can do for each item in the sequence, either to exhaustion or in thirty seconds. He determines the number he can do simply by performing a trial run through the circuit. Half this number constitutes his training level for three complete turns of the circuit. The time taken to do this is the initial circuit time. On the basis of the initial time the supervisor arbitrarily assesses for the subject a target time at which he can aim. When the individual succeeds in performing the circuit within the target time higher levels of performance and a new target time are determined by repeating the above procedure.

Standard circuits have been designed with constant repetitions and poundages for each item. Progression is made from moderate to severe circuits and variations can also be made within the circuit by emphasising either strength or endurance training.

The writer feels that a different method of training will develop strength and endurance better because previous methods lack intensity. The method of Interval Circuit Training as used in this study employs the principles of interval running. This method of developing fitness

consists of nearly maximal efforts spaced by short recovery periods.

The hypothesis of this study is that Interval Circuit Training as a method of physical fitness training is superior to the other three methods selected. The study is limited to fourteen to sixteen year old boys taking part in a Junior High School programme of physical education.

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CHAPTER II

JUSTIFICATION OF THE PROBLEM

A problem which occurs frequently in circuit training with large numbers of students is the delay experienced by the performer at some items. This handicap may be overcome to a certain extent by staggering the starting points of different individuals. It may also by remedied by halving the group and by allowing one half to perform while the other supervises and then reversing the roles. However, this latter procedure leaves little time for further activity in a forty-five minute period.

Hellebrandt and Houtz (1) consider that the sub-maximal loads, which circuit training uses, stimulate little tension in muscles. Müller (2) regards the development of tension as the major training stimulus and Clarke (3) has suggested that the overload principle has not been adequately applied in fitness training methods.

The method of Interval Circuit Training developed in this study includes work with maximal or nearly maximal resistance for short time periods spaced with small rest periods. Strength and endurance are developed separately, with the endurance training following the strength training. On the other hand strength and endurance training proceed together in the standard methods of Circuit Training.

Since repetitions in the Interval Circuit resistance training are necessarily small, the working atmosphere is swift and intense; little delay can occur even with large numbers. Performance is more easily checked by the instructor and the whole group may work together. Recent theories of isometric strength development by Hettinger and

Müller (4) show that nearly maximal contractions held for a period of six seconds have a beneficial training effect even though the resistance is not moved.

The Interval Circuit contains twelve items each of which has three constant repetitions. The target time for the twelve events is two minutes, followed by a one minute rest-pause. Five successive two-minute turns complete the whole circuit which is immediately followed by an endurance run between one and one-half and two miles.

As a performer tires a smaller weight at an event can become his maximum resistance, according to the principles of MacQueen (5).

This study has been undertaken because no work has been done on the problem of devising a comprehensive fitness training method within the framework of a school physical education programme. It is an attempt to measure the relative effectiveness of Interval Circuit Training in a school physical education programme.

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CHAPTER III

REVIEW OF LITERATURE

In an early experiment by Adamson (1) half a class of fourteen to fifteen year old boys in a secondary school took part in a circuit training routine. This programme was done three times a week for a month and was in addition to their normal physical education programme. The other half of the class received no additional activity. The groups were matched and randomly assigned either to the control or exercise group. At the end of the month they were retested on the same initial tests, McCloy's Athletic Strength Index, The Harvard Step Test and a Physical Efficiency Index consisting of standing broad jump, shot put and body weight measures. The exercise group showed significant gains over the control group in all three variables. In the Harvard Step Test the control group even showed a negative gain, indicating that there could be a loss in fitness as measured by this test for students participating in the normal physical education programme. The method developed from this experiment by Morgan and Adamson (2) called Circuit Training has become widely used for improving physical fitness.

Circuit Training emphasizes the use of exercises incorporating resistance supplied either by the body itself or by the use of weights. However, in both cases relatively large numbers of repetitions are done with sub-maximal loads. On the other hand Cerutty (3) says that the best weight to be used to develop strength is close to an individual's maximum. McMorris and Elkin (4) seem to agree with Cerutty indicating that the stimulation of muscular hypertrophy by sub-maximal work was often not accompanied by strength gains.

Several workers have investigated strength gains resulting from work with heavy weights. MacQueen (5) showed that gradual reduction of the muscle load as it fatigues provides sufficient training effect. The work of Hellebrandt and Houtz (6) indicated that both strength and endurance improved when work was done against heavy resistance. In addition the gradient of the training curve varied with the stress, frequency and duration of exercise. Repetitions with inadequate stress had little effect in strength training. Müller (7) considers the key factor in strength development to be tension. Tension in the muscle decreases as the speed of contraction increases; the use of heavy resistances requiring a longer contraction time is therefore better suited to strength development.

Steinhaus (8), in a review of the ideas of strength training, outlined new concepts of the value of isometric and isotonic contraction. Studies by Lorback and Swegan (9) at Pennsylvania compared the effectiveness of these methods in developing muscle strength. Other studies notably by Adamson (10), (11), Darcus and Salter (12), Matthews and Kruse (13), and Rarick and Larsen (14), have indicated a wide conflict of opinion with regard to the merits of these two methods. Clarke (15) has suggested that many studies in strength improvement have had inadequate training periods, that the overload principle has not been applied and that much work remains to be done in determining the most effective utilization of exercise methods.

Merton (16) investigating the problem of muscular fatigue found that a short rest period is needed by a muscle after exhaustion before it

can show a maximum contraction again. Previous investigation by Müller (17) also showed that when exercise is heavy a larger amount of work can be done if the exercise is interspersed with rest pauses. Clarke, Shay and Mathews (18) estimated the optimum length of the rest period to be in the region of two and one half minutes. Darcus (19) found that in fatigue, other muscles besides the fatigued muscle begin to contract, effecting whole body exercise. Rasch and Morehouse (20) found a certain specificity of the movement patterns in repetitive resistance exercises.

There are no indications that repetitive maximum work with rest pauses has been used in a circuit method. This kind of training is well known in athletics as interval training and Stampfl (21) has called it the most exhaustive of all, producing high standards in running efficiency. Cerutty (22) has used the method of heavy resistance work in repeated runs up eighty foot high sandhills. Work by Balke and Ware (23) has also shown that endurance running is an efficient method of improving cardiovascular endurance correlating well with maximum effort runs on the tread mill. Jokl (24) found that the hearts of athletes, especially those active in the endurance sports of running, cycling and swimming more so than in the strength sports of weightlifting, wrestling and judo, were significantly stronger than the hearts of non athletes. The suggestion seems to be therefore that a duality in the training method embracing the efforts of maximal strength work and endurance running is desirable. Wolffe (25) has refuted the idea of over exertion and strain as a special peril of adolescence. He has reported that no cardiologist of standing has indicated this.

He also claims that all reported cases of death and injury in physical activity have revealed some prior undiscovered pathological condition.

Larson (26) has shown that a dynamic strength index consisting of chins, dips and vertical jump is three times more significant than dynamometer tests in predicting a composite index of motor ability. Brouha (27) introduced the step test as a general test of the body's capacity, in particular that of the cardiovascular system, to adapt itself to and recover from hard exercise.

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CHAPTER IV

METHODS AND PROCEDURE

Composition of Groups

The study used four equated groups of fourteen to sixteen year old boys for one period per school week. Their normal physical education programme consisted of three physical education periods and one health class per six day school week. Therefore specific training was given once every eight days.

Each of the four equated groups followed a different training routine. These routines were Interval Circuit Training, Circuit Training with Endurance Running, Circuit Training followed by a Games Activity andan entire Games Programme.

Each group consisted of thirteen boys. The pupils were matched on the basis of their scores on the McCloy's Classification Index (1), The Larson Strength Test (2) and the Harvard Step Test (3). Therefore all four groups were classified and matched with respect to age weight and height and performance. One period per week the boys were instructed by the writer and during the rest of their programme by the school physical education teacher. No specific training in strength or endurance was given during the rest of their programme throughout the period of the experiment. Both training and testing were done at the same time of day.

Administration of the Tests

For administration of the tests the boys were divided into pairs to observe and record each other's performance. The classification index was computed from the age, weight and height of the boys by

means of the formula:-

Index = 20 x (Age in years) + 6 x (Height in inches) + Weight in pounds.

The Larson Strength Test required the subject to complete as many pull-ups and dips as he could and to jump as high as possible. The pull-ups were done with the hands in the overgrasp position and the feet clear of the ground. The subject was instructed to raise his chin to the bar when his arms were bent and to fully extend the arms in relaxation. No kicking was allowed and the number of complete chins was counted by the boy's partner. Dips were done on the parallel bars. The subject jumped to the high support position on the bar. He was instructed to lower his body until the upper and lower arms made an angle of ninety degrees at the elbow, and then to push himself up to full extension again. A short rest was allowed between chinning and dipping. In the Vertical jump, the subject was first required to touch as high as possible on a wall scale with both hands above his head and his toes touching the wall. This height was recorded. He then stood sideways and jumped to touch as high as possible on the scale. The tips of the fingers were chalked. A crouch and arm swing were allowed and the best of three trials was taken as the vertical jump. The difference in inches between the initial readings and final chalk marks was read to the nearest half inch. This test was administered by two instructors. The raw scores obtained on all these tests were converted by means of tables in a manual (4) into weighted scores and summed for each subject. The index corresponding to this

sum, read from another table in the same manual was called the Dynamic Strength Factor.

The Harvard Step Test required the subject to step up and down on a bench eighteen inches high for five minutes at the rate of one step every two seconds. The pulse rate was measured for thirty seconds at one, two and three minutes respectively from the end of the exercise. For the purposes of this experiment, where the full number of steps (150) was not done, the actual number of steps completed was used in computing the index, rather than assigning arbitrary scores to the subject. The formula used to calculate the index was:-

$$\text{Index} = \frac{100 \times \text{Number of Steps}}{\text{Sum of the three pulse counts}}$$

The stepping rhythm was counted by an instructor, and the pulse rates were counted by the boy's partners under conditions of silence and supervision. The above index when multiplied by a factor of 2/3 was called The Endurance Factor.

For the purpose of the experiment scores on these two factors were added so that a Total Fitness Factor could be obtained. Thus:-

Strength Factor + Endurance Factor = Total Fitness Factor.

Group Activities

The Interval Circuit Group

This group performed on a special circuit emphasizing maximal resistance (see Table 1, page 18). There were twelve items in the circuit. The number of repetitions of each item was three. The

weights were comparatively heavy, but the performer, as he became tired, could use a lighter weight. When he was unable to move either himself or the weight through the full range of movement he was instructed to hold a maximum contraction for six seconds. The duration of the circuit was always the same-two minutes followed by a one-minute rest. Time overspent by an individual on the circuit was deducted from his rest periods. Thus everyone always began together. At the end of five such circuits, the two miles run was performed.

The Circuit-Run Group

This group used standard circuits of varying intensity with sub maximal resistances. Progression was made when pupils achieved the target time for their particular circuit (see Table 2 page 19). On completing the circuit training they immediately ran two miles.

The Circuit-Activity Group

The Circuit-Activity group performed on the same standard circuits as the above group. They took part as a class which had been halved to accommodate a large number of pupils. Thus they first supervised the Circuit-Run group and when this group departed to do the running they performed themselves under the supervision of the physical education instructor. Any time left at the end of the period was given over to games.

The Activity Group

The Activity group played games during their training period. The game varied from week to week consisting of basketball, soccer, volley-ball, football, and softball. They took no part in specific circuit training or endurance running.

All the circuit training groups were motivated by the time factor associated with the circuits. In addition, the endurance running groups had full knowledge of their weekly run times.

Items in the Circuits

The items and number of repetitions for both types of circuit training are shown in Tables 1 and 2 on pages 19 and 20 respectively. It may be noticed that the five standard circuits of the circuit training groups differ only in the amount of resistance used and the number of repetitions done.

All members of the classes performed the training. No one knew who was in the experimental groups.

DESCRIPTION OF THE INTERVAL CIRCUIT

Table 1.

	Item	Poundage
1.	Barbell Press	45 lbs, 55 lbs, 65 lbs, 85 lbs.
2.	Barbell Curl	45 lbs, 55 lbs, 65 lbs, 85 lbs.
3.	Barbell Reverse Curl	45 lbs, 55 lbs, 65 lbs, 85 lbs.
4.	Barbell Tricep Snatch	45 lbs, 55 lbs, 65 lbs, 85 lbs.
5.	Barbell Rowing	45 lbs, 55 lbs, 65 lbs, 85 lbs.
6.	Dumbell Side Bends	1 x 10 lbs 1 x 25 lbs.
7.	Dumbell Straddle Jumps	2 x 10 lbs 2 x 25 lbs.
8.	Dumbell Lying Lateral Raise	2 x 10 lbs 2 x 25 lbs.
9.	Bench Press	35 lbs, 45 lbs, 65 lbs.
10.	Chins	10 lbs, 20 lbs, (suspended from shoulders)
11.	Sit Ups	10 lbs, 15 lbs, 20 lbs (Held behind head)
12.	Trunk Extension	10 lbs, 15 lbs, 20 lbs.

Two Mile Run

The training programme consisted of the following:-

1. Completing in two minutes three repetitions of each item with the maximum weight which could be moved.
2. Resting one minute.
3. Repeating the whole circuit as above 5 times.
4. Any individual not completing the circuit in 2 minutes had the overtime deducted from the rest period.
5. As the performer tired a lower weight would become a maximum for him, free choice of weights was allowed for each item.
6. Any movement not able to be completed was held for six seconds.
7. At the end of the 5th lap the two mile run was immediately performed.

DESCRIPTION OF FIVE STANDARD CIRCUITS USED

BY THE CIRCUIT TRAINING GROUPS

Table 2

ITEM	Circuit I	Circuit II	Circuit III	Circuit IV	Circuit V
1. Sit Ups	15	15	15	15	15
2. Chins	3	5	5	5	6
3. Shuttle Run	3	3	3	2	2
4. Step Ups	15	15	12	15	15
5. Straddle Jump	5*	5*	8*	8*	8*
6. Squat Thrusts	12	12	15	15	15
7. Trunk Extention	10	15	10**	10**	10**
8. Push Ups	10	10	12	12	12
9. Barbell Curl	5**	5**	8***	8***	8***
10. Barbell Press	5**	5**	8***	8***	8***
Target Times	10.00 mins	11.00 mins	10.00 mins	10.30 mins	10.00 mins
Poundages	* 5 lbs	* 10 lbs	* 15 lbs	* 15 lbs	* 15 lbs
			** 5 lbs	** 10 lbs	** 10 lbs
	** 25 lbs	** 35 lbs	*** 45 lbs	*** 55 lbs	*** 65 lbs

In performance of a circuit the ten items constitute one turn of the circuit. Three turns must be completed in the target time, before the individual can attempt the next higher circuit.

The Circuit Training Activity Group supervised The Circuit Training Endurance Run group before they themselves attempted the circuit. This was done in order to simulate conditions which would occur with a large class needing to be split in half and practiced separately. The Circuit Endurance Run group went on a two mile run immediately after all of them had finished their circuit. The Circuit Activity group joined the Games group immediately after completing the circuit.

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CHAPTER V

RESULTS

TABLES SHOWING MEANS AND STANDARD DEVIATIONS OF INITIAL AND FINAL SCORES.

Table 3. Total Fitness Factor

Grp.	No.	$\bar{X}_{int.}$	$S_{int.}$	$\bar{X}_{fin.}$	$S_{fin.}$	$\bar{D}$	$S_{\bar{D}}$
I	13	113.53	12.83	126.76	9.64	13.23	7.10
II	13	111.23	13.80	120.92	14.91	9.69	10.61
III	13	112.23	15.28	118.61	17.04	6.38	7.27
IV	13	113.30	10.39	120.30	14.86	7.00	12.44

This table shows the relative Efficiency of the initial matching of the groups in terms of the Means and Standard Deviations of initial scores.

$\bar{X}_{int.}$ Mean of Initial scores

$\bar{X}_{fin.}$ Mean of Final scores

$\bar{D}$ Mean difference between Initial and Final scores

$S_{int.}$ Standard Deviation of Initial Scores

$S_{fin.}$ Standard Deviation of Final Scores

$S_{\bar{D}}$ Standard Deviation of difference between Initial and Final Scores.

Table 4. Dynamic Strength Factor

Grp.	No.	$\bar{X}_{int.}$	$S_{int.}$	$\bar{X}_{fin.}$	$S_{fin.}$	$\bar{D}$	$S_{\bar{D}}$
I	13	58.53	11.88	68.00	12.25	9.46	9.90
II	13	60.85	10.61	66.92	12.37	6.07	6.43
III	13	58.15	11.23	63.92	13.39	5.76	5.25
IV	13	63.30	9.76	67.23	12.37	3.92	12.59

$\bar{X}_{int.}$ Mean of Initial scores

$\bar{X}_{fin.}$ Mean of Final Scores

$\bar{D}$ Mean difference between Initial and Final scores

$S_{int.}$ Standard Deviation of Initial Scores

$S_{fin.}$ Standard Deviati on of Final scores

$S_{\bar{D}}$ Standard Deviation of difference between Initial and Final scores.

Table 5. Endurance Factor

Grp.	No.	$\bar{X}_{int.}$	$S_{int.}$	$\bar{X}_{fin.}$	$S_{fin.}$	$\bar{D}$	$S_{\bar{D}}$
I	13	55.00	5.83	58.76	6.06	3.76	8.56
II	13	50.38	9.40	54.00	7.22	3.61	6.80
III	13	54.07	10.08	54.69	8.43	0.61	4.20
IV	13	50.00	11.06	53.07	6.87	3.07	6.56

$\bar{X}_{int.}$ Mean of Initial scores

$\bar{X}_{fin.}$ Mean of Final scores

$\bar{D}$ Mean difference between Initial and Final scores

$S_{int.}$ Standard Deviation of Initial scores

$S_{fin.}$ Standard Deviation of Final scores

$S_{\bar{D}}$ Standard Deviation of Difference between Initial and Final scores.

Table 6. Gains in Scores made by the Groups from Initial to Final Tests on the Total Fitness, Dynamic Strength and Endurance Factors

	Grp. I $\bar{D}$	Grp. II $\bar{D}$	Grp. III $\bar{D}$	Grp. IV $\bar{D}$
Total Fitness	13.23	9.69	6.38	7.00
Dynamic Strength	9.46	6.07	5.76	3.92
Endurance	3.76	3.61	0.61	3.07

Table 7. Differences between the groups on Total Fitness factor

		$\bar{d}$	$SE_{\bar{d}}$	Obtained t	Accept or Reject Hypothesis	E.A*
Group I	- Group II	3.54	3.66	0.97	Accept	0.40
Group I	- Group III	6.84	3.60	1.90	Reject	0.10
Group I	- Group IV	6.23	3.25	1.92	Reject	0.10
Group I	- Group III	3.30	3.35	0.99	Accept	0.40
Group II	- Group IV	2.69	4.03	0.67	Accept	0.50
Group III	- Group IV	3.75	-0.62	-0.17	Accept	0.50

The Null hypothesis tested was that **no difference occurred in the** gains between the groups taken two at a time.

*Extreme Area showing the limits of the Critical Region for the obtained t scores.

Table 8. Differences between Groups on Dynamic Strength Factor

	$\bar{d}$	$SE_{\bar{d}}$	Obtained t	Accept or Reject Hypothesis	E.A*
Group I - Group II	3.38	4.25	0.80	Accept	0.50
Group II - Group III	3.69	3.30	1.12	Accept	0.40
Group I - Group IV	5.53	4.40	1.37	Accept	0.20
Group I - Group III	3.30	3.20	0.14	Accept	0.50
Group II - Group IV	2.69	4.32	0.50	Accept	0.50
Group III - Group IV	-0.62	3.72	0.50	Accept	0.50

The Null hypothesis tested was that **no difference occurred in the** gains between the groups taken two at a time.

*Extreme Area showing the limits of the Critical Region for the obtained t scores.

Table 9. Differences between Groups on Endurance Factor

		$\bar{d}$	$SE_{\bar{d}}$	Obtained t	Accept or Reject Hypothesis	E.A*
Group I	- Group II	0.16	2.86	0.06	Accept	0.50
Group I	- Group III	3.15	2.67	1.48	Accept	0.20
Group I	- Group IV	0.69	3.01	0.23	Accept	0.50
Group I	- Group III	3.00	2.44	1.23	Accept	0.40
Group II	- Group IV	0.53	2.08	0.26	Accept	0.50
Group III	- Group IV	-2.46	3.15	-0.78	Accept	0.50

The Null hypothesis tested was that **no difference occurred in the** gains between the groups taken two at a time.

*Extreme Area showing the limits of the Critical Region for the obtained t scores.

CHAPTER VI

DISCUSSION

The study shows that significant gains were made by the Interval Circuit Group over both the Circuit Training-Activity Group and the Activity Group in the Total Fitness Factor. No significant gains were made by any group over any other factors. Although it is logical to expect parallel improvement in measures of endurances in both groups which had endurance running during training it is noticeable that there was no significant gains made by either of these Groups over the Circuit Training-Activity or Activity Groups in this factor.

The insignificant differences found between each of the two Circuit Training groups and the Activity group does not parallel the findings of Adamson (1). This is probably due to the differing conditions of the experiments. In the latter case the Circuit Training was given three times a week in addition to a normal programme for a month. In the present study the special training period was given as part of the programme once every eight days for two months and even then was restricted in the case of the Circuit Training-Activity Group.

The superior performance of the Interval Circuit group on the tests may be due to experience gained in applying intense effort. Ikai and Steinhaus (2) have indicated that even though capacity is a measure of the physiological limit, the actual performance is itself limited by psychological factors - especially in any test where maximum effort is needed.

Limitations and errors in the method of the experiment were controlled to some extent since these were common to the groups compared

in the study. No attempt was made therefore to measure them. No absolute interpretation has been made of the scores on the three factors and only differences between scores have been studied within the population of fourteen to sixteen year old boys in The Junior High School.

Cureton (3) has shown the insufficiency of the Harvard Step Test as an indicator of cardiovascular efficiency when training in its method is not given previous to the testing. Although a separate study (4) showed the increased predictive quality of it when this training is given these conditions are not represented in this study, where only tests at the beginning and end of the experiment were possible.

The matched group statistical treatment provides a powerful test of the null hypothesis proposed. The level of significance chosen was deemed sufficient for the two tailed test used since consequences of a Type II error were considered to be of importance to the study. The Extreme Areas of all the obtained t scores have been reported as a matter of interest.

Further work in this area may investigate whether an increased frequency and period of training would give more significant differences than shown here.

CHAPTER VII

SUMMARY AND CONCLUSIONS

Ever since progressive resistance methods have been applied to fitness training a large measure of controversy has developed concerning the best organization of such methods into a generally applicable training regime. The rival claims of isometric and isotonic methods have been especially interesting. Circuit Training sought to combine into one system many of these modern ideas but it seems to lack somewhat in the intensity of effort required for the highest development.

Four methods of developing physical fitness have been compared in this study. Three of the methods used progressive resistance exercises and, in addition, two involved endurance running. One of the resistance methods organized the resistances and repetitions of the circuit differently from the generally accepted method and combined them with endurance running. When done in this form the training was called Interval Circuit Training. The other methods involved (1) conventional Circuit Training with Endurance running, (2) Circuit Training and Games Activity and (3) only Games Activity.

Four groups of fourteen to sixteen year old boys in a Junior High School programme were used in the study. The groups were matched by equating each boy in each group with one boy in each of the other groups on the basis of an age, height and weight index, a dynamic strength factor and an endurance factor.

The four groups took part in their separate training programmes once every eight days for two months at the end of which time they were retested on the same initial tests. During the period of the

experiment they were motivated by a full knowledge of their progress.

Differences between matched individuals in the gains achieved by them from the initial to the final tests were compared by means of a statistical test of the null hypothesis that there was no difference between the gains made by the groups taken two at a time.

The effects of the training methods on the separate factors of Total Fitness, Dynamic Strength and Endurance were compared. It is apparent from the results that the Interval Circuit Training method was more efficient than the Circuit Training-Activity and the Activity methods but not significantly more efficient than the Circuit Training-Endurance Run method. The fusion of the isometric and isotonic methods with the use of maximal resistances may be the vital factor responsible for the superiority of the Interval Circuit Training Method.

The use of Circuit Training in situations which necessitate dividing a class into halves and running them separately through the circuit in order not to cause delays results in each half practicing for only half the period. Such an arrangement does not seem to have any apparent superiority over a pure games programme.

Further research into the effectiveness of Interval Circuit Training might resolve the contribution made by the experience gained from intense effort in the training process. Increase in the frequency and length of the training period together with a superior evaluation of the fitness factors would also indicate more clearly the areas of improvement.

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APPENDIX

APPENDIX A

STUDY DESIGN

I	$\bar{X}_{initial}$	Experimental Factor: Interval Circuit Training →	$\bar{X}_{Final}$	$\bar{D}$ $(\bar{X}_{Final}-\bar{X}_{initial})$
II	$\bar{X}_{initial}$	Experimental Factor: Circuit Training, Endurance Running →	$\bar{X}_{Final}$	$\bar{D}$ $(\bar{X}_{Final}-\bar{X}_{initial})$
III	$\bar{X}_{initial}$	Experimental Factor: Circuit Training, Games Activity →	$\bar{X}_{Final}$	$\bar{D}$ $(\bar{X}_{Final}-\bar{X}_{initial})$
IV	$\bar{X}_{initial}$	Experimental Factor: Games Activity →	$\bar{X}_{Final}$	$\bar{D}$ $(\bar{X}_{Final}-\bar{X}_{initial})$

APPENDIX A

STATISTICAL TREATMENT

$H : \mu_d = 0$

Alternatively

$H_1 : \mu_d > 0$

$H_2 : \mu_d < 0$

Level of Significance

α = 0.1 two tailed test

Critical Region of t score for this value of α (12 df)

$R_1 : t \geqslant 1.78$

$R_2 : t \leqslant -1.78$

$$t \ (df \ (N-1)) = \frac{\bar{d} - \mu_d}{SE_{\bar{d}}} = \frac{\bar{d}\sqrt{N-1}}{S_d}$$

$\bar{d}$ Mean difference of gains occurring between groups

df Degrees of Freedom

N Number in sample

$SE_{\bar{d}}$ Standard Error of Mean differences

S_d Standard Deviation of the differences

APPENDIX B

INDIVIDUAL SCORE SHEET

Name Age Height (inches) Weight (lbs) Grade

McCloy's Classification Index

20 x (Age in years) + 6 x (Height in inches) + Weight in pounds

____

Larson Strength Index

	Raw Score	Weighted Score
Chins		
Dips		
Vertical Jump (inches)		

Total _____

Norm Score Strength Factor ____

Harvard Step Test

Number of Steps completed
Time of exercise in seconds

Pulse counts

1-1½ min. from end of exercise
2-2½ min. from end of exercise
3-3½ min. from end of exercise

Total _____

Physical Fitness Factor = $\frac{\text{Number of Steps x 100}}{\text{Sum of Pulse Counts}}$ ____

Endurance Factor = $\frac{\text{2/3 Physical Fitness Factor}}{}$ ____

Total Physical Fitness Factor = Endurance Factor + Strength Factor

APPENDIX C

RAW SCORES

RAW SCORES OF THE INTERVAL CIRCUIT GROUP

TABLE 10

Name	Strength Factor				Endurance Factor				Total Fitness Factor		McCloys Index	
	Weighted Score		Norm Score		Pulse Count		Norm Score					
	I	F	I	F	I	F	I	F	I	F	I	F
1. B.C.	150	218	31	48	148	135	57	66	88	114	836	836
2. P.W.	212	279	60	78	146	175	69	57	129	135	773	778
3. J.S.	290	366	65	84	163	185	61	54	126	138	873	877
4. R.F.	288	384	65	89	180	171*	55	53	120	142	854	854
5. D.M.	281	341	63	78	182	174	55	57	118	135	861	874
6. T.G.	242	289	55	65	161	155*	62	55	117	120	877	877
7. B.B.	225	262	49	58	181	150	51	60	100	118	858	866
8. E.R.	223	301	50	69	190*	207	48	48	98	117	835	844
9. J.B.	360	337	83	77	188	159	51	63	134	140	854	863
10. J.M.	256	249	66	64	203	156	49	64	115	128	781	780
11. G.B.	232	235	66	67	205	190	49	53	115	120	772	780
12. W.M.	226	252	51	57	182	148	55	67	106	124	823	822
13. D.D.	257	230	57	50	164	150	53	67	110	117	875	878

*Indicates performance of less than 150 steps

APPENDIX C

RAW SCORES

RAW SCORES OF THE CIRCUIT TRAINING

ENDURANCE RUN GROUP

TABLE 11

Name	Strength Factor: Weighted Score		Strength Factor: Norm Score		Endurance Factor: Pulse Count		Endurance Factor: Norm Score		Total Fitness Factor		McCloys Index	
	I	F	I	F	I	F	I	F	I	F	I	F
1. B.B.	136	184	45	60	240*	174*	27	37	72	97	736	741
2. V.J.	231	235	75	76	157*	172	53	58	128	134	723	721
3. R.W.	249	254	64	65	183	211	55	47	119	112	793	793
4. B.M.	301	268	68	60	180*	163	49	61	117	121	854	865
5. B.K.	248	255	55	56	173	193	57	52	112	108	852	874
6. J.R.	241	305	55	70	165*	186	55	54	110	124	832	844
7. G.O.	237	269	61	69	187	167	48	60	109	129	809	812
8. D.K.	219	254	41	48	173*	176	47	49	88	97	896	901
9. B.M.	323	383	75	90	194	184	50	55	125	145	819	830
10. R.T.	276	287	71	74	195	201	51	48	122	122	812	815
11. D.W.	212	270	69	87	159*	170	49	59	118	146	727	722
12. J.M.	243	232	55	53	181	151	55	66	110	119	834	848
13. T.B.	229	243	57	62	168	179	59	56	116	118	796	798

*Indicates performance of less than 150 steps

APPENDIX C

RAW SCORES

RAW SCORE OF THE CIRCUIT TRAINING-ACTIVITY GROUP

TABLE 12

	Name	Strength Factor				Endurance Factor				Total Fitness Factor		McCloys Index	
		Weighted Score		Norm Score		Pulse Count		Norm Score					
		I	F	I	F	I	F	I	F	I	F	I	F
1.	D.M.	188	208	54	59	214*	177*	28	30	82	89	748	751
2.	G.H.	261	281	67	72	163	166	61	60	128	132	786	799
3.	D.P.	351	410	68	80	170	166	59	60	127	140	896	903
4.	G.C.	157	183	45	52	144	153	69	65	114	117	769	779
5.	B.M.	350	341	67	66	209	194	48	51	115	117	908	915
6.	W.T.	323	350	75	82	184	186	55	54	130	136	821	829
7.	D.P.	188	184	54	53	170	173	56	58	110	111	746	758
8.	T. G.	162	184	34	39	168*	176	51	49	85	88	848	854
9.	J.F.	268	288	61	65	146	163	69	62	130	127	841	840
10.	J.M.	246	266	69	75	201	197	50	51	119	126	766	766
11.	T.G.	247	319	63	83	207	170	48	59	111	142	784	784
12.	G.C.	213	221	47	49	174	175	57	57	104	106	826	823
13.	B.M.	203	221	52	56	206	183	52	55	104	111	798	799

*Indicates performance of less than 150 steps

APPENDIX C

RAW SCORES

RAW SCORES OF THE ACTIVITY GROUP

TABLE 13

Name	Strength Factor: Weighted Score		Strength Factor: Norm Score		Endurance Factor: Pulse Count		Endurance Factor: Norm Score		Total Fitness Factor		McCloys Index	
	I	F	I	F	I	F	I	F	I	F	I	F
1. E.L.	243	240	54	53	315*	275*	15	40	69	93	872	879
2. J.B.	295	326	76	84	160*	178	54	56	130	140	806	816
3. R.F.	305	367	69	85	174	204	57	49	126	134	856	863
4. J.K.	272	263	70	68	174	157	59	64	129	132	812	814
5. G.W.	264	326	60	74	195	192	51	52	111	126	841	846
6. H.C.	271	238	60	52	175*	187	50	53	110	105	870	869
7. J.F.	273	349	61	80	217	173	46	57	107	137	874	873
8. B.T.	237	287	45	53	178*	183*	46	45	91	98	938	940
9. N.R.	349	283	81	65	189	178	53	56	134	121	830	832
10. S.L.	263	196	74	56	159*	178*	47	49	121	105	754	756
11. D.M.	169	227	55	73	167	189	60	53	115	126	718	729
12. B.L.	229	230	57	52	180	152	55	66	112	118	824	824
13. G.R.	186	244	61	79	187*	181*	57	50	118	129	738	738

*Indicates performance of less than 150 steps

APPENDIX C

MASTER SCORES

GAINS IN THE TOTAL FITNESS FACTOR FOR THE FOUR MATCHED GROUPS

TABLE 14

	Interval Circuit	Circuit-Run	Circuit-Activity	Activity
1.	26	25	7	24
2.	6	6	4	10
3.	12	-7	13	8
4.	22	4	3	3
5.	17	-4	2	15
6.	3	14	6	-5
7.	18	20	1	30
8.	19	9	3	7
9.	6	20	-3	-13
10.	13	0	7	-16
11.	5	28	31	11
12.	18	9	2	6
13.	7	2	-7	11

APPENDIX C

MASTER SCORES

GAINS IN THE DYNAMIC STRENGTH FACTOR FOR THE FOUR MATCHED GROUPS

TABLE 15

	Interval Circuit	Circuit-Run	Circuit-Activity	Activity
1.	17	15	5	-1
2.	18	1	5	8
3.	19	1	12	16
4.	24	-8	7	-2
5.	15	1	-1	14
6.	10	15	7	-8
7.	9	8	-1	19
8.	19	7	5	8
9.	-6	15	4	-16
10.	-2	3	6	-18
11.	1	18	20	18
12.	6	-2	2	-5
13.	-7	5	4	18

APPENDIX C

MASTER SCORES

GAINS IN THE ENDURANCE FACTOR FOR THE FOUR MATCHED GROUPS

TABLE 16

	Interval Circuit	Circuit-Run	Circuit-Activity	Activity
1.	9	10	2	25
2.	-12	5	-1	2
3.	-7	-8	1	-8
4.	-2	12	-4	5
5.	2	-5	3	1
6.	-7	-1	-1	3
7.	9	12	2	11
8.	0	2	-2	-1
9.	12	5	-7	3
10.	15	-3	1	2
11.	4	10	11	-7
12.	12	11	0	11
13.	14	-3	3	-7

APPENDIX C

MASTER SCORES

DIFFERENCES IN GAINS OF MATCHED SETS IN TOTAL FITNESS FACTOR

TABLE 17

I Interval Circuit Group
II Circuit Run Group
III Circuit-Activity Group
IV Activity Group

	I-II	I-III	I-IV	II-III	II-IV	III-IV
1.	1	19	2	18	1	-17
2.	0	2	-4	2	-4	- 6
3.	19	-1	4	-20	-15	5
4.	18	19	19	1	1	0
5.	21	15	2	- 6	-19	-13
6.	-11	-3	8	8	19	11
7.	- 2	17	-12	19	-8	-29
8.	10	16	12	6	2	- 4
9.	-11	9	19	23	31	10
10.	13	6	29	-7	16	23
11.	-23	-26	-6	-3	17	20
12.	9	16	12	7	3	- 4
13.	5	0	-4	-5	-9	- 4

APPENDIX C

MASTER SCORES

DIFFERENCE IN GAINS OF MATCH SETS IN THE ENDURANCE FACTOR

TABLE 18

I Interval Circuit Group
II Circuit-Run Group
III Circuit-Activity Group
IV Activity Group

	I-II	I-III	I-IV	II-III	II-IV	III-IV
1.	-1	11	-16	12	-15	-27
2.	-17	-11	-14	6	3	- 3
3.	1	- 8	1	- 9	0	9
4.	-14	2	- 7	16	7	- 9
5.	7	- 1	1	- 8	- 6	2
6.	- 6	- 6	-10	0	- 4	- 4
7.	- 3	7	- 2	10	1	- 9
8.	- 2	2	1	4	3	- 1
9.	7	19	9	12	2	-10
10.	18	14	13	- 4	- 5	- 1
11.	- 6	- 7	11	- 1	17	18
12.	1	12	1	11	0	-11
13.	17	11	21	- 6	4	10

APPENDIX C

MASTER SCORES

DIFFERENCE IN GAINS OF MATCHED SETS IN THE DYNAMIC STRENGTH FACTOR

TABLE 19

I Interval Circuit Group
II Circuit-Run Group
III Circuit-Activity Group
IV Activity Group

	I-II	I-III	I-IV	II-III	II-IV	III-IV
1.	2	12	18	10	16	6
2.	17	13	10	- 4	- 7	- 3
3.	18	7	3	-11	-15	- 4
4.	32	17	26	-15	- 6	9
5.	14	16	1	2	-13	-15
6.	- 5	3	18	8	23	15
7.	1	10	-10	9	-11	-20
8.	12	14	11	-12	-11	- 3
9.	-21	-10	10	11	31	20
10.	- 5	- 8	16	- 3	21	24
11.	-17	-19	-17	- 2	0	2
12.	8	4	11	- 4	3	7
13.	-12	-11	-25	1	-13	-14

APPENDIX D

DIAGRAMS

FIGURE I

Diagram of Layout of Circuit

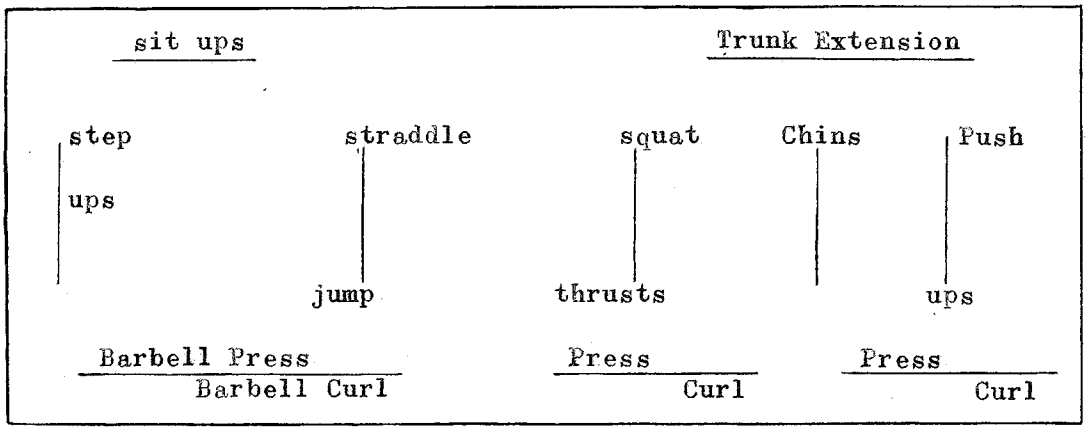

FIGURE II

Diagram of Layout of Interval Circuit