THE EFFECT OF CIRCUIT TRAINING UPON CARDIOVASCULAR CONDITION AND MOTOR PERFORMANCE

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ABSTRACT

The purpose of this study was to evaluate the effectiveness of a twice-weekly thirty-minute circuit training class in improving the Cardiovascular condition and motor performance of male freshmen enrolled in the Required Physical Education Programme at the University of British Columbia. An experimental sample of twenty subjects was selected randomly from one of the eight circuit training classes but this number was reduced to fifteen by the end of the term.

A statistical comparison of the experimental group with a large sample of first year students tested in 1962 was made for height, weight and four motor performance items. The two groups were found to be sufficiently alike to consider the experimental group as reasonably representative of male college freshmen enrolled in the required programme of the University.

The subjects were given a twenty-seven item fitness test battery prior to and at the end of the ten week circuit programme. The gains in fitness measures were evaluated by an analysis of the reliability of mean differences for each test item, a conversion of the mean test scores into standard scores from scoring tables for normal young college men in order to determine mean standard score improvement, and an analysis of the number of students who, between tests, increased their scores, decreased their scores, or remained the same. These results were then compared with those obtained from a physical conditioning programme study which utilized the same tests, procedures and time spent in training between tests.

In almost all the variables studied, approximately three-quarters of the subjects showed changes which were in the direction of increased physical

fitness. All of the twenty-seven items used showed mean changes in the direction of increased physical fitness and twenty-two of them were statistically significant. These included all the motor performance items and eight of thirteen cardiovascular condition items.

Each individual showed a somewhat unique pattern of changes in cardiovascular condition. Several subjects with relatively high scores on their initial tests had lower scores when they were retested and some subjects who had relatively low initial scores showed higher scores on re-test. The rest of the subjects, in general, increased their scores on retest.

The training programme was adequate to produce fair improvements in cardiovascular condition in the initially unfit students. Factors extraneous to the study appeared to influence those subjects who scored high initially but then regressed on retest. The training programme seemed sufficient in duration or intensity (or both) to produce improvement in motor performance.

The circuit training programme was found to be superior to the physical conditioning programme in improving most aspects of physical fitness.

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STATEMENT OF THE PROBLEM

The problem was to determine whether or not participation in a programme of 'circuit training' twice a week for ten weeks would produce improvements in the motor performance and cardiovascular condition of male freshmen students at the University of British Columbia.

A. Delimitations

(1) The study dealt with one circuit training class in the Required Physical Education Programme.

(2) The class consisted of twenty-five male freshman students.

(3) The experimental study was conducted over a ten week period (one semester).

(4) A fixed or standard circuit (1) was used in which the loads (resistance and repetitions) and the time of performance were pre-set.

(5) Twelve motor performance factors were tested in the major areas of strength, endurance, power, speed, agility and flexibility.

(6) Fifteen factors of cardiovascular condition were tested using extra-corporeal methods.

B. Limitations

(1) The testing personnel could not be classified as experts in the fields of motor performance and cardiovascular testing.

(2) Psychological apprehension (2) of the subjects was not controllable although it is an important influence in motor performance and cardiovascular tests.

(3) Psychological drive on motivation (3) of the subjects during performance both in the circuit and in the tests was impossible to determine.

(4) The relationship of body type, physique and anthropometric characteristics to motor performance (4) and cardiovascular condition tests (5) was not taken into account in this study.

(5) Experience and learning that are a result of preliminary testing were also uncontrollable factors.

(6) It was not feasible to control diet (6) during this study.

C. Basic Assumptions

(1) Muscular strength and muscular endurance (dynamic strength), static strength, power (explosive strength), speed, agility (speed of change of direction), and extent flexibility are components of motor performance (7) and the tests selected represent methods by which these components may be measured.

(2) Stroke volume (blood ejection velocity from the heart), endurance in short hard work, vagus tone and splanchnic ptosis are components of cardiovascular condition (8) and the tests selected represent methods by which these components may be measured.

(3) Any changes in measurements made are primarily due to changes in

motor performance and cardiovascular condition and not due to learning or differences in motivation.

D. Terminology

Since current terminology in this field is neither consistent nor precise it is necessary to briefly define the terms used in this experimental study.

Total Fitness: ".... that state which characterizes the degree to which a person is able to function. It implies the ability of each person to live most effectively within his potentialities. Ability to function depends upon the physical, mental, emotional, social and spiritual components of fitness, all of which are related to each other and are mutually interdependent." (9).

Physical Fitness: "the development and maintenance of a strong physique and soundly functioning organs, to the end that the individual realizes his capacity for physical activity, unhampered by physical drains or by a body lacking in strength and vitality" (10).

Motor Fitness: ".... a limited phase of motor ability which emphasizes capacity for vigorous work or athletic effort .... It emphasizes the fundamental or gross big muscle movements that are dominated by Kinesthetic sense, and suppleness of the major tissues and joints, i.e., those aspects which are fundamental to athletic or work skills rather than the higher refinements pertaining to specialized small muscle skills which require years to perfect" (11). It is also known as 'physical (motor) fitness' or more specifically 'motor performance'.

Strength: ".... the capacity of the body, or the hands or legs to exert great force" (12).

Explosive Strength: ".... the ability to exert maximum energy in one explosive act" (13). It is also known as 'power' in some studies.

Dynamic Strength: ".... the strength of muscles in the limbs in moving or supporting the weight of the body repeatedly over a given period of time" (14).

Static Strength: "the capacity of an individual to exert muscular force against a resistance, maximum muscular strength being measured by use of a near - immovable resistance under isometric conditions" (15).

Muscular Endurance: "the capacity of an individual for continuous performance of relatively heavy localized activities which make only small demands on the functions of circulation and respiration before local fatigue terminates performance" (17). This factor is also known as 'static' endurance.

Flexibility: ".... the capacity of the body to move easily to the full range of joint flexion and extension without undue restrictions in the joints or tissues" (18), including emphasis on rapid recovery from this strain allowing an immediate repetition of the movement (19).

Extent Flexibility: ".... the ability to move or stretch the body, or some part thereof, as far as possible in various directions" (20).

Agility: ".... the capacity for fast reaction in controlled movement where 'accuracy' is also a feature" (21). It is also known as 'speed of change of direction'.

Speed: ".... the ability of the individual to make successive movements of the same kind in the shortest period of time" (22).

Cardiovascular Condition: "both the heart and the blood vessels are muscular organs which are capable of contracting and relaxing in ways which move the blood continuously around the body. The efficiency with which this is done is called cardiovascular condition" (23). This is also variously known as 'cardiovascular fitness', cardiorespiratory fitness', or 'circulatory endurance'.

Cardiovascular Component I (24): This component is Stroke Volume or something very closely akin to it, such as blood ejection velocity from the heart or force of the heart systole, and tends to be a reflection of sympathetic autonomic tone. It has been shown to contribute 29.04% of the total variance in the entire complex of cardiovascular fitness.

Cardiovascular Component VI (25): This measure has been tentatively called Endurance. In short hard work or 'dynamic endurance: ".... represents the individual's capacity to continue submaximal contractions of a number of muscle groups with sufficient intensity to make demands on the functions of respiration and circulation before general fatigue terminates performance" (26). It contributes 5.08% to total variance.

Cardiovascular Component VII (27): This component has been tentatively called Vagus Tone and is dominated by pulse rate; the slower the pulse rate the higher the vagus tone (28). The contribution to total variance is 3.92%.

Cardiovascular Component VIII (29, 30): This component is usually called Splanchnic Tone but considered negatively it can also be called Circulatory Ptosis and refers to the pooling of the blood in the large leg and abdominal veins. It relates to the mechanism of splanchnic accommodation and contributes 3.44% to total variance.

Note: Though Cureton has called some of the three pulse counts after five minute stepping exercise a test of vagus tone, there is some doubt that pulse rate after exercise is reflecting vagus tone more than to a very small degree. The rapidity with which the pulse rate returns to normal is probably due to other reflexes and adjustments in the cardiovascular system. It is possible that this component should be called 'Pulse Rate Recovery After Exercise", and it is significant that this is exactly the title given to this test by Cureton prior to the study by Cureton and Sterling in Journal of Sports Medicine and Physical Fitness, vol. 4, (March, 1964), pp. 1-24, 1964.

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CHAPTER II

JUSTIFICATION OF THE PROBLEM

"Physical fitness, or specifically a lack of it, is a topic of national interest and importance" (1). This is clearly indicated by the recent action of the Canadian Government in passing Bill C-131, An Act to Encourage Fitness and Amateur Sport, under which it plans to invest five million dollars yearly for physical fitness and amateur sport.

The Royal Commission on Education in the Province of British Columbia, according to its published report (2), is heartily in accord with the aim of maintaining and improving the physical health and fitness of the youth of the province (3).

The concern is such that from time to time, The University Required Physical Education Programme comes under criticism due to the lack of objective evidence of the benefits of the activities in the programme to the participating students. The following excerpt is representative of comments that occurred in the briefs and at the hearings of the Commission: No. 132: "Since the Kraus-Weber tests have proven that the physical condition of Canadian youth is progressively deteriorating in spite of our physical education programme, we can consider this programme a failure and it should be abolished as it is time consuming and wasteful" (4).

In order to satisfy the objective of physical fitness it is the policy of the University of British Columbia and many other institutions to include compulsory participation in a "fitness activity" in the physical education requirement. 'Circuit training' is one of the several 'fitness activities' offered.

From a survey of University physical education, the Royal Commission on Education considered that there should be a strengthening of the programme with regard to exercise (5).

Up to the present time there has been no comprehensive study completed concerning the benefits derived from the Required Physical Education Programme, in particular, the motor performance and cardiovascular condition of those male freshmen students enrolled at the University of British Columbia who participate in the circuit training programme. Recently a University committee has recommended that members of the Physical Education School should study the effects of required programme activities on the physical fitness of freshmen students on the campus.

Circuit training is a relatively recent method of fitness training and there has been very little experimental research completed concerning its effects on the components of motor performance and cardiovascular condition. Although circuit training has a world-wide reputation as an effective means of improving physical fitness, objective data are needed to show: (a) whether or not this reputation is justly deserved, (b) the extent to which each of the various components of physical fitness is changed by circuit training, and (c) whether or not it is better than other training programmes carried out with the same regularity. If data show that the components of motor fitness are changed differentially, it should then be possible to improve the design of the circuit to produce more equable effects.

The 'circuit' in use at the University of British Columbia, designed by members of the physical education faculty, has been in use for several years with required programme students training twice a week for ten weeks in the first or second term. Therefore it seems important to determine whether or not this programme operated under these particular conditions is really effective and to determine its strength and weaknesses in improving physical fitness (in terms of motor performance and cardiovascular condition).

Since much of the Canadian winter climate is detrimental to outdoor training, circuit training, if proven to be effective, could become a valuable method of obtaining and maintaining year-round physical fitness.

This study concerning the circuit training programme is an initial step in providing evidence on the basis of which an intelligent judgement may be made concerning the value of this programme.

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CHAPTER III

REVIEW OF THE LITERATURE

Physical Fitness: Karpovich (1) claims that the equipment that enables a man to meet the requirements of his labor and to combat adverse influences is partly inborn and partly acquired. He classifies this equipment into three major categories: morphologic, physiologic and psychologic. The morphologic consists of the physical form and structure determined largely by heredity and also by use. The physiologic are organs which by graded and frequent use yield capacity for adjustment in activity. The psychologic is the mind, the master of the body machine which acquires greater capacity and adjustment with graded and proper use (2).

Thus it is evident that "physical fitness is really a convenient label for what is rarely if ever purely physical" (3). Yet a physical element can be identified and is basic. It is this identifiable physical phase of fitness involving both organic health and capacity to perform that must be isolated as the primary objective of physical education. Willgoose (4) claims:

> "Physical education is a potentially powerful force in present day society... But the potential value will not be reached by merely working on social efficiency and mental-emotional adjustment goals that all education are interested in. Physical education will be most effective when it does the unique thing which it can do best. Certainly it must give attention to all present goals, but the objective of physical fitness must take precedence over the rest."

Gallagher and Brouha (5) have divided physical fitness into three major areas: medical, functional and motor performance fitness. The soundness of the organs of the body is estimated by conventional examination in medical fitness to discover obvious defects. Functional or organic fitness is the capacity to perform and recover from maximal or sub-maximal exercise. Motor performance fitness is the ability to perform certain acts requiring strength flexibility and skill These last two aspects of functional fitness and motor performance fitness are considered in this experimental study.

Keeney (6) feels that physical fitness can be assessed directly by performance tests (motor performance fitness) and indirectly by inference from the manner in which the individual's heart rate, blood pressure and other physiologic variables respond to a specified work load (cardiovascular condition).

That motor performance is indeed different from cardiovascular condition is discussed by Fowler and Gardner (7). Comparison of American children with boys and girls from other countries in motor performance tests has implied that American children are woefully unfit. Yet, according to life expectancy, American youth is more fit than ever before, and comparison of cardiovascular tests have failed to show significant differences between European and American children (8). According to Fowler and Gardner (9) "This discrepancy originates from the assumption that tests of motor performance and skills are related to functional fitness, or that any physical fitness test can be correlated with health or longevity".

Motor Performance Fitness: Motor fitness is the practical approach to physical fitness. Brock, Cox and Pennock (10) state:

> "Motor fitness is the final criterion through which all other elements of physical fitness are seen and measured in man. How continuously and efficiently he performed his daily work in industry, on the farm, in the armed forces or in athletic performances, was at one time the only criterion that man had of physical fitness. He might know little or nothing about scientific facts of body structure, or the functioning of the organs strength tests on the dynamometer, or organic efficiency tests but he could understand an outstanding performance displaying power, speed and endurance."

Further, it concerns the capacity for efficient performance in the fundamental skills of "running, jumping, dodging, falling, climbing, swimming, lifting weights, carrying loads and enduring under sustained effort in a variety of situations" (11). These fundamental skills may be further divided into basic elements such as strength, power, speed, agility, flexibility and balance (12).

The primary concern in motor fitness is the measurement of performance in physical activities in order to determine the major component of ability factors which underlie the physical proficiency or the effective utilization of the organic factors of development.

Nicks and Fleishman (13) carried out a critical review and integration of previous factor analysis studies concerning the criteria of physical proficiency. The results indicated fourteen factors of motor performance fitness. Of these, the factors tested in this study include: Explosive Strength (Power), Dynamic Strength and Endurance, Static Strength, Extent Flexibility, Agility and Speed.

<u>Cardiovascular Condition:</u> Cureton (14) states: "The value of physical education and athletics to improve motor fitness is quite obvious and many of us understand it. However, there are many aspects of fitness that we do not understand. One is the value of physical education and athletics to improve cardiovascular condition."

According to Henry (15), circulatory adjustments to the stress of physical activity and the manner of return to the resting base line are important aspects of exercise physiology, because blood flow is closely related to the vital factor of oxygen transportation to the body tissues. While the resting circulation is of less direct impact, it is of interest because it may reflect (indirectly) certain physiological changes resulting from athletic training that are advantages during exercise.

Henry (17) maintained that cardiovascular changes in 18 college athletes during training compared with 15 controls, can be interpreted as the result of the interplay of basic factors (peripheral resistance, aortic-volume, elasticity, stroke volume, and heart rate). The observed effect of athletic training seem to be due to increased elasticity and resting stroke volume associated with a compensating decrease in heart rate. Brachial pulse wave configurations (systolic amplitude) differentiate athletes from controls but do not change by a statistically acceptable amount during training. Changes in the resting heart rate constitute a useful test of cardiovascular aspect of athletic conditioning, the validity being $r = 0.76$.

Studies have been reported showing that with direct pressure measurements the pulse wave amplitude is related to stroke volume (18). Michael (19) showed the same thing to be true using the Heartometer pulse wave. Starr (21), however, has indicated that stroke work and not stroke volume is related to the amplitude of the wave. Starr felt that the stroke work related to the ejection velocity or steepness of the pulse wave slope.

Massey et al (20) found that the systolic and diastolic amplitudes of the heartogram would differentiate good condition from poor condition at the 5 percent level of confidence. The pulse rate change was also significant at the 5 percent level.

Cureton (22), summarizing all the studies completed at the University of Illinois, reported the brachial wave recorded with the subject quietly sitting not only correlated with running endurance but also differentiated groups believed to differ in cardiovascular fitness.

Cureton and Sterling (16) carried out a multiple factor analysis of 104 cardiovascular test variables under well standardized conditions. The results showed eight factors other than weight. The extent to which each factor samples the total complex of cardiovascular condition was indicated by percent of total variance. Of these factors, those utilized in this study include: (Stroke Volume (Blood Ejection Velocity from the Heart), Vagus Tone, Splanchnic Ptosis and Endurance in Short Hard Work.

<u>Circuit Training</u>: A number of special exercise systems have been proposed which are designed to develop various physical fitness components

by group methods. Circuit training (23) is one of these exercise systems. It has developed over the years out of a search for a method of fitness training that would appeal to students and would, at the same time, progressively develop general muscular and circulorespiratory condition. It evolved out of an attempt to find a method of training which would enable the average student to acquire some of the high level of stamina of the distance runner, together with some of the strength of the weightlifter and the speed of the speed of the sprinter.

A 'circuit' as such consists of a number of carefully selected and simple-to-perform exercises, that are arranged in the form of a circuit around the gymnasium (numbered consecutively), in such a manner as to enable large numbers of students to proceed from one exercise to another without undue local fatigue, and at a work rate compatible with each student's capacity. The exercises include the use of weights (including handling of total body weight) as well as general endurance exercises such as squat thrusts.

Circuit training is a form of progressive resistance loading (24) and is designed to improve general physical fitness rather than fitness required for any particular activity or game. The amount of work done per second seems to be the critical variable (25) on which extension of limits of performance depends and the principle of progressive loading (26) appears to supply the answer to the problem of control of fitness qualities by work rate. Progressive resistance for strength and power, either by imposition of progressively greater loads or high work rate, produces increases in muscle strength by fiber hypertrophy and neuromuscular conditioning. As a result of this increase in strength, fewer motor units of the muscle are required for a given load and these may be alternated over a longer period of time thus increasing muscular endurance. Specific progressive resistance for muscular endurance is effected through perfection of movement and improved blood supply to the muscle. Progressive loading of activities such as exercises involving severe leg work, in addition to increasing the strength and muscular endurance of the muscles concerned, induces hypertrophy and increased capillarization of cardiac and peripheral muscle, thereby increasing circulorespiratory endurance.

Current research on endurance training suggests that it must involve a progressive resistance loading of the circulorespiratory system over long periods of time (27), examples being Fartlek training, Interval Training and Repetition Training. However, no single type of exercise seems capable of developing both strength and endurance. Weight training seems to have little or no effect of circulo-respiratory condition.

Circuit training which is really interval exercising, endeavors to obtain both strength and endurance effects by timed control of submaximal training (28). The individual aims to do more work in a fixed time or the same work in less time.

This type of fitness training includes the following advantages (29, 30, 31):

(1) The participant starts off easily and is able to experience some degree of success early in the programme.

(2) The participant is one of a class, but is not asked to do anything beyond his own capabilities each day.

(3) The participant, when ready, progresses to an individual circuit, based on his own maximum performance. Progression is assured.

(4) The participant works inconspicuously among the other class members and is free from continuous direction from the instructor.

(5) The instructor is free to supervise and provide individual attention where necessary.

(6) Large numbers can work at the same time.

(7) The specific exercises to be performed in the circuit will depend on the conditioning effects sought. The circuit selected should have a positive effect on muscular power, muscular endurance, strength and circulo-respiratory endurance.

(8) The exercises are easily standardized, so that the participant is able to perform the same way each day. (See Appendix E).

(9) The participant knows exactly how he progresses each day. He can set a daily goal and objectively see how he is progressing toward the target time. The time factor provides a built-in motivation to do better, or push oneself.

(10) The participant competes only against himself. A weaker person can complete a circuit at a lower level of work in the same

time as a stronger person working at a higher level. Work is equated.

(11) Circuit training is based on the work rate of the individual and employs the principle of "progressive loading", which is the same as the overload principle. However, in circuit training, one does not continuously increase the weight load, but decreases the time it takes to perform the circuit, plus increasing the number of repetitions per exercise at specific times.

(12) As a method of training, it utilizes three variables (load, repetitions and time). No other training regime provides this. Weight training provides only loads and repetitions. Interval running provides only repetition and time. As a result, circuit training affects strength, muscular endurance and circulo-respiratory endurance simultaneously.

As an all-round developer of physical fitness, circuit training does have a place in physical education, but according to Lewis (32) it does have certain limitations for its use in activity programmes. In his article he did not intend to detract from the contributions circuit training has made in modern physical education, but to point out that it should be used for what it was intended - general fitness. Its applicability to all situations he feels was not intended. The limitations are as follows:

(1) Most sports have certain specific kinds of fitness peculiar to that sport. Circuit training won't meet this need.

(2) There is no development of relaxation and a sense of balance specific to different sports.

(3) Hurried movements and reduction of work-time in circuit training do not achieve the best results for certain needs in sports.

If these limitations are recognized, according to Lewis, then circuit training could be used as a basic conditioner for sports.

Though circuit training is a fairly recent innovation on this continent, its use has been indicated in a number of other articles (33, 34, 35).

Review of Circuit Training Studies:

Circuit training is a relatively recent innovation in the field of fitness training. Limited experimental research has been carried out on its effects on components of physical fitness.

Morgan and Adamson (36) performed an experiment with progressive loading which led to circuit training. The boys (aged 14 to 15) were in two balanced groups which had three physical education periods per week. The experimental group had an additional overload program amounting to 30 minutes per week for one month. Gains in the experimental group over the control group indicated that a relatively small amount of intensive overload training, using apparatus normally found in schools, produced significant increases in strength, efficiency and fitness indices.

Nunney (37) equated two groups of 12 college men on the basis of distance swum in a 15 minute endurance test using the front crawl only. Both groups were also tested for swimming speed over 33 1/3 yards, height, weight and ability to perform dips, chins, vertical jumps and push-ups. The experimental group combined circuit training and swimming in the program; the control group performed swimming only. It was found that the experimental group made significant gains in swimming endurance and speed, weight and ability to perform chins and push-ups. The control group made significant gains in swimming endurance and weight. The experimental group made significantly greater gains than the control group in weight and chins.

Brown (38) concluded that a physical education program for fifth grade girls which included a 10 minute circuit training program improved physical fitness, as measured by the AAHPER Youth Fitness Test.

Forty-two businessmen from the Vancouver YMCA were equated by Taylor (39) into three groups (one underwent a program of calisthenics, another a circuit training program, and the third acted as a control group). All subjects were given the Larson Muscular Strength Test and the Harvard Step Test at the beginning and the end of the 8 week experimental period. Both experimental groups showed gains in performance that were statistically significant for the cardiovascular and muscular strength tests. There were no statistically significant differences between the two experimental groups. It was concluded that both the calisthenics and the circuit training programs, as used in this study, were effective methods of improving the cardiovascular and muscular status of business men.

In a study by Watt (40), one group of 21 subjects was subjected to a developmental course of exercises at the University of Oregon. A second group of 17 subjects went through a developmental course in which circuit training was used. The subjects were tested in pull-ups, push-ups, leg lift, 300 yard, shuttle run and 60 second sit-up test before and at the end of the course. Watt found that significant gains in the physical fitness level of low fitness students can be achieved by their participation in either of the two programs used. He concluded that improvement in the performance of the cardio-respiratory test (300 yard run) can be increased significantly by the regular developmental course exercises or by circuit training.

Forty college freshmen were randomly selected by Johnson and Kubek (41) from three required physical education programme classes at the University of British Columbia. The three classes were circuit training, weight training and physical conditioning. All subjects were given the Larson Muscular Strength Test and the Harvard Step Test at the beginning and end of the 8 week experimental period. The circuit training group showed significant improvement over the physical conditioning group in all three factors: strength, endurance and total physical fitness. It also showed significant improvement over the weight training group in the endurance and total physical fitness factor but not the strength factor. From this study it appeared that circuit training is a more effective method of improving muscular strength and endurance within the scope of the study. (The circuit used in this study was different than the one used in the present study).

Two studies have been completed which use the identical circuit as administered in this study.

In a study by Howell et al (42) two groups of 17 freshmen at the University of Alberta were equated on the basis of the Modified Step Test. The experimental group participated in circuit training twice a week for four weeks. The control group participated in the regular service programme of volleyball and badminton for approximately 30 minutes twice a week. At the end of the experimental period the group were tested using the modified Harvard Step Test. The results indicated that the circuit training group gave a statistically significant improvement in the modified Harvard Step Test ($t = 4.94$) while the control group showed no statistically significant gains ($t = 1.56$). Eight sessions of circuit training spread over four weeks produced significant changes in the circulo-respiratory function as measured by the Modified Harvard Step Test at the one percent level.

Brown (43) selected twenty male first year students participating in the required physical education circuit training programme and gave each the Cureton-3-Item Endurance Test (chins, sitting tucks, and one mile run) prior to a ten week program of circuit training. At the end of this time the test was repeated and the gains in all three items were significant at the 5 percent level of confidence. Two students failed to improve in chinning and two failed to improve in the mile run. Everyone improved in the sitting tucks. It was concluded that circuit training was beneficial in increasing the all-around muscular endurance of the individual.

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CHAPTER IV

METHODS AND PROCEDURES

Statistical Design: The experimental design used in this study is known as the "single group" method or the "one-group" technique (1) wherein the same tests are administered to the same group and separated by a specific time interval.

Experimental Group: One of eight circuit training classes in the Required Physical Education Programme at the University of British Columbia was selected at random for the purpose of choosing students to participate in this experimental study. By drawing names from a hat, twenty students were randomly selected from the class to engage in this study. However, by the end of the term, this number was reduced to fifteen due to an assortment of injuries and personal problems.

The age of these subjects, taken to the closest half-year, ranged from seventeen to twenty-one years with the mean age being 18.9 years. Height taken to the closest half-inch and in bare feet, ranged from 67 to 76 inches, with the mean height being 71 inches. Weight, taken to the closest half-pound, ranged from 130 to 190 pounds. The mean weight was 157.3 pounds.

These students had no previous circuit training experience nor were they taking part in any other regular exercise during the term. No subject indicated an intention to enter the professional physical education programme.

At the initial test session, subjects were asked to subjectively rate their level of physical fitness. Three subjects rated themselves as being in 'good' condition, ten felt they were in 'fair' condition and two thought their fitness level was 'poor'.

Control Group: In all experiments involving an interval of time during which significant change in subjects would normally take place, it is desirable and necessary to know the normal or expected performance of the group, to serve as a basis of comparison with the results produced by manipulation of the experimental variable. Thus the results at the end of the time interval can be interpreted only in comparison with normal performance for a group of similar intelligence and home background while following the usual activity procedure (2).

It has been fairly well established that with other environmental variables reasonably controlled, the individual's state of physical fitness will be proportional to the amount of training done. Wolfson (3) determined the effects of a programme of prescribed exercises on the physical fitness of adult men. He found that while the training group improved significantly in measures of cardiovascular and motor fitness, a control group showed negligible change. Other studies (4,5,6,7,8) have shown that less vigorous activities, such as volleyball and badminton, produce relatively small positive changes in fitness when compared with more vigorous activities such as weight training, conditioning exercises and circuit training.

In light of this objective data showing that changes in physical fitness variables of young men are insignificant in inactive and even mildly active control groups, it was considered more valuable to use the limited time available in measuring a larger number of tests than would have been possible if a 'live' control group had been employed in the study.

In order to determine the effects of other environmental variables which might have influenced the level of fitness of the test sample, a Health Habit Questionnaire was distributed to each subject both at the initial and final tests. (See Appendix D). This attempted to determine any changes in personal and health habits which might have markedly influenced physical fitness of the subjects. Habits of concern were smoking, rest, nutrition and exercise.

In place of a 'live' control group, Norms for College Men were utilized as published by AAHPER (9) and Cureton (10,11).

The Circuit Training Programme: The circuit training programme (12) at the University of British Columbia consists of 13 different exercises at separate stations, each performed according to a prescribed number of repetitions and load. There are six different levels of performance at each station permitting five steps of progression. These steps are labelled Red 1, 2 and 3; Blue 1, 2 and 3. All the subjects begin at Red 1 and perform three entire laps of the circuit in their own time. When a subject is able to complete the circuit three times in 25 minutes he progresses to the next level (Red 2). The circuit used is shown in Table 1. The subject's time and level of performance are self-recorded for each trial on the circuit. The exercise procedure is given in Appendix B.

TABLE I

CIRCUIT TRAINING EXERCISES? WEIGHTS AND REPETITIONS
AT EACH STATION (U.B.C. CIRCUIT)

Station	Exercise	Red Circuit Wgt. in Pounds	1	2	3	Blue Circuit Wgt. in Pounds	1	2	3
1.	Squat Thrust	-	10	12	15	-	18	21	25
2.	Two Arm Reverse Curl	40	8	10	12	50	8	10	12
3.	Two Arm Press	50	8	10	12	60	8	10	12
4.	Straddle Bench Jumps	15	15	17	19	25	17	18	19
5.	Lateral Raise	$7\frac{1}{2}$	8	10	12	10	8	10	12
6.	Lying Lateral Raise	10	8	10	12	15	8	10	12
7.	Sit Ups	-	10	14	18	-	21	25	30
8.	Bench Step Ups	-	15	17	20	-	23	26	30
9.	Jump Chins	-	1	2	3	-	4	6	8
10.	Bench Press	60	6	8	10	80	6	8	10
11.	Trunk Extension	-	10	12	14	-	16	18	20
12.	Bent Over Rowing	65	6	8	10	85	6	8	10
13.	Stair Running	-	6	8	10	2x10	6	8	10

Test Battery: In attempting to obtain a comprehensive evaluation of the state of fitness possessed by an individual it is necessary then to test as many of the major components as possible. It follows from this that test validity may be improved by increasing the size and scope of the test battery. This principle is illustrated by Cureton (13) who, while referring to the optimum prediction of physical fitness in terms of motor fitness tests, states: "It is possible to improve the validity of Motor Fitness by adding the Mile Run and Strength to the all-around 18 - item Motor Fitness Test". By doing so Cureton was able to increase validity from an R of 0.659 to 0.763.

With reference to test battery size Karpovich (14) states:

> "It is obvious, that with more numerous test items, more information can be obtained about the individual. Efforts are made, however, to select those items that can reveal the most and thus reduce the number of tests. The use of too many tests is impractical...."

The establishment of a competent physical fitness test battery will depend primarily on the compromising of two principles.

Firstly, the number of test items must be large enough to give a comprehensive picture of the main components of physical fitness. Secondly, the size of the test battery must be small enough to be administratively feasible in terms of time and economy.

Another prime consideration in selecting items to test the various components of fitness is that of scientific feasibility. This must be in terms of reliability, objectivity and validity.

Motor Performance and Cardiovascular Condition were chosen as the media through which physical fitness would be evaluated.

A. Cardiovascular Condition

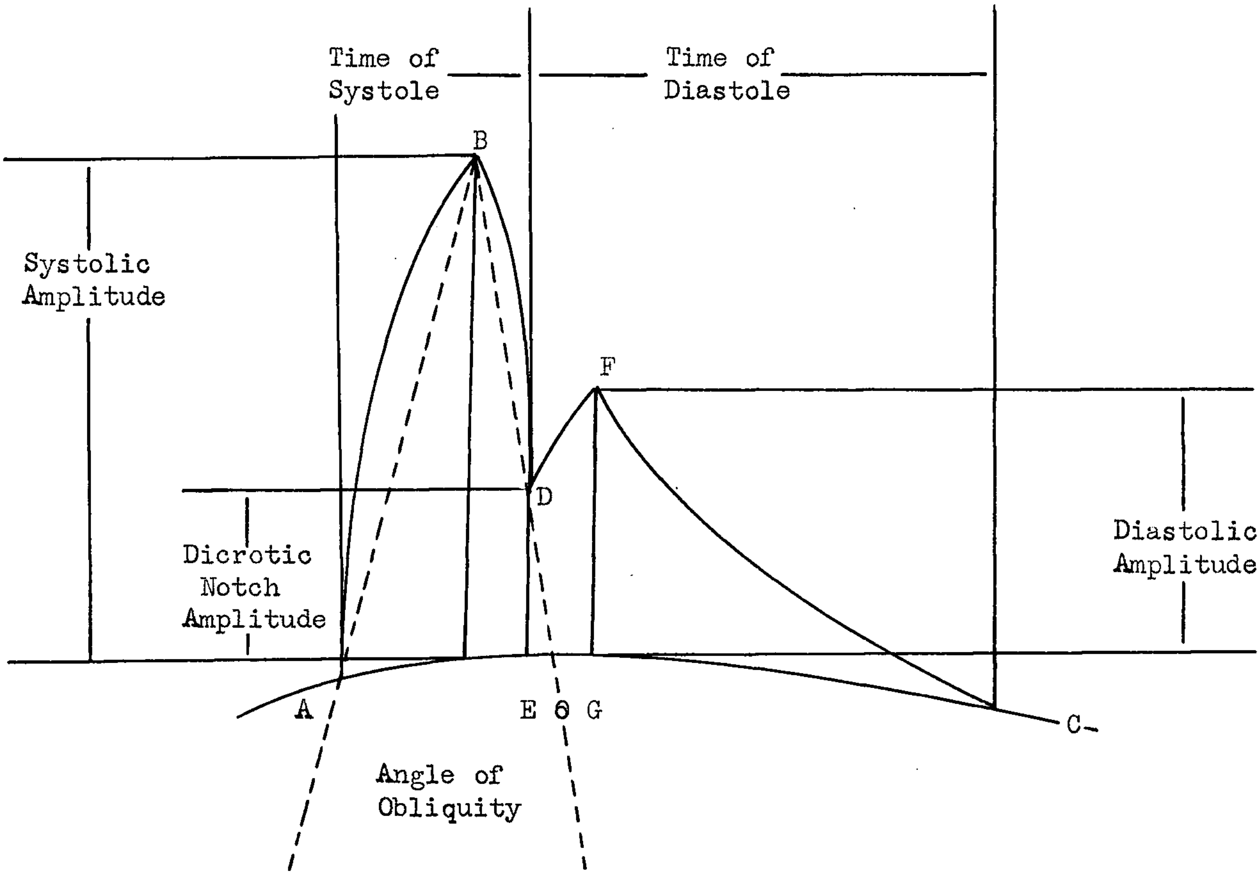
The Cameron Heartometer (Brachial Sphymograph) (15) provides a graphic record made by a pen activated by the pulsations of the brachial artery transmitted by blood pressure apparatus of the sphygmograph type. The writing pen is activated by air pressure and leverage. The energy of the pulse wave is shown vertically and time lapse is shown horizontally. The heartograph differs from the electrocardiograph in that it registers variations of mechanical pressure rather than electrical variations. It has been validated against endurance items that included distance running, distance swimming, treadmill running and step test performance.

According to Cureton (16), the Cameron Heartometer furnishes systematic and objective records of systolic and diastolic blood pressure, pulse pressure, heart rate and heart valve actions. Cureton suggests that one of the uses of the Heartometer is that of "Prediction of the relative state of 'functional cardiovascular condition' in subjects without heart disease".

Reliability ratings for the Heartometer measurements range from 0.719 to 0.928 according to Willet (17). Validity of the various items of predictions of All-Out Treadmill Running ranged from R's of 0.012 to 0.448.

FIGURE I

CAMERON HEARTOGRAPH MEASUREMENTS (18):



(a) Selected Heartograph Measurements: (See Figure I above and Appendix F).

<u>Item 1</u> - Area Under Curve (ABDFCA):- reflects somewhat the blood pumped per stroke of the heart and also tone of the wall of the brachial artery and its branches. A strong cardiovascular system usually gives a graph which has relatively more area under the average single cycle and this area is thought to be somewhat proportional to a stronger systolic and a stronger 'diastolic squeeze', the latter being the force from the aorta

propelling the blood into the systemic circuit after the closing of the semi-lunar valves and also to the tone of the connecting arteries and peripheral vessels. The splanchmic tone is also reflected in this measurement. (See Appendix F).

Item 2 - Systolic Amplitude Sitting (A,B):- indicates the magnitude of myocardial action due to contraction of the ventricles. A low amplitude suggests a heart with relatively weak stroke during systole. Psychological excitment, due to apprehension on fear undoubtedly causes over-action of the vaso-constriction system and the secretion of adrenalin in unusual amounts into the blood. The immediate response is a stronger systole and faster heart rate.

Item 3 - Systolic Amplitude Standing

Item 4 - Systolic Amplitude After 1' Run In Place

Both of these measures tend to reflect the stroke volume of the heart.

Item 5 - Diastolic Amplitude (FG):- represents that part of the cycle which occurs after the semi-lunar valves close. A larger amplitude indicates a more forceful rebound of the secondary wave.

Splanchnic tone is also reflected in this measure.

Item 6 - Dicrotic Notch Amplitude (ED):- indicates a level of cardio-vascular tone, i.e. it is proportional to the diastolic blood pressure which acts as back pressure to close the semilunar valves. If the elastic rebound of the aorta and other principal vessels is relatively strong (Splanchnic Tone), the pressure is transmitted mechanically through the blood to close the semilunar valves quickly. To close the valves this back pressure must be greater than the pressure in the heart ventricles. Fatigue of the autonomic nervous system and smooth musculature of the aortic arch seems a reasonable explanation as to why this measure is lowered, but dilation of the arterioles and capillaries may be a greater causal factor.

Item 7 - Angle of Obliquity (ABO):- The significance of this angle may be the fact that a slow acting heart muscle, due to weakness or sluggish heart tissue, gives a greater angle because more time is taken for the upward systolic stroke to the maximum point. In such a case it is inferred that the heart muscle has difficulty overcoming the resistance of the blood column above the semilunar valves or that there is interval resistance in the heart tissue itself. This measure tends to have a high correlation with the systolic amplitude.

Item 8 - Diastolic Time (EC):- measures the time of diastole from the closing of the semilunar valves. This measure is used in computing the Rest/Work Ratio.

Item 9 - Systolic Time (AE):- measures the time of systole from the closing of the semilunar valves. A strong fast systole seems generally desirable in young subjects at rest as contrasted with a sluggish systole.

Item 10 - Rest/Work Ratio (EC/AE):- this measurement is the ratio of the systole contraction to the overall time of the diastole. With increased efficiency there is a trend toward a longer resting phase and a larger ratio. A strong efficient cardiovascular system has a high ratio of 4 to 1; an average system is 1.89 to 1; a poor system is lower than 1.21 to 1.

Item 11 - Systolic Amplitude Sitting to Standing:- tends to reflect the splanchnic accommodation as a result of change of position, the Systolic Amplitude Sitting being larger than the Systolic Amplitude Standing. The smaller the difference, the better is the splanchnic tone.

Item 12 - Pulse Rate (as counted on heartograph):- the regular rate of heart beat taken in beats per minute. A slow rate is fairly highly correlated with endurance performance in track running.

This item has a factor loading of -0.60 with Vagus Tone and -0.46 with Stroke Volume. This suggests that the pulse rate is negatively correlated with the systolic amplitude of the pulse wave (19). Thus a basis is given for believing that the brachial pulse wave is an indication of sympathetic tone, the tone being relatively greater when the wave is taller and sharper.

Two other theories of slower heart rate in individuals with somewhat higher sympathetic tone include increased capillarization (20) and the presence of sympathetic vasodilation fibers in the coronary arteries of the heart (21).

(b) Other Cardiovascular Condition Items:

Item 13 - 600 Yard Run-Walk:-

Classification: measure of cardiovascular endurance.

Purpose: to determine time necessary to cover 600 yards. This is a test of endurance in short hard work.

Reliability: Larson and Yocom (22) maintain that any test of running 150 yards and up has a high reliability (0.90 and above).

Validity: use of this measure in the AAHPER Youth Fitness Test is an indication of its accepted validity (23).

Item 14 - Illinois Five Minute Step Test:-

Classification: measure of cardiovascular tone.

Purpose: to determine a total pulse count for 30 seconds at 1, 2 and 3 minutes after stepping up and down on a 17 inch bench at 30 per minute for 5 minutes. This is a test of vagus tone.

Reliability: 0.78 - 0.87, Cureton (24).

According to Cureton and Sterling (25) the components of Cardiovascular Condition may be evaluated with these test items as follows:

Component I - Stroke Volume (Blood Ejection Velocity from the Heart)

Item 1	Heartometer	-	Area Under Curve
Item 2	Heartometer	-	Systolic Amplitude Sitting
Item 3	Heartometer	-	Systolic Amplitude Standing
Item 4	Heartometer	-	Systolic Amplitude After Exercise
Item 5	Heartometer	-	Diastolic Amplitude
Item 6	Heartometer	-	Dicrotic Notch Amplitude

Item 7 Heartometer - Angle of Obliquity

Item 8 Heartometer - Diastolic Time

Item 9 Heartometer - Systolic Time

Item 10 Heartometer - Rest/Work Ratio

Component VI - Endurance In Short Hard Work

Item 13 600 Yard Run-Walk

Component VII - Vagus Tone

Item 12 Heartometer - Pulse Rate

Item 14 Five Minute Step Test

Component VIII - Splanchnic (Circulatory) Ptosis

Item 1 Heartometer - Area Under Curve

Item 11 Systolic Amplitude (Sitting - Standing)

Factor loadings of most of these items with the four cardiovascular components are given in Appendix F.

B. Motor Performance

Selected Motor Performance Test Items

Item 1 - Illinois Agility Run:- According to Larson (26) the agility component factor of motor fitness may be evaluated in a moderately objective and reliable manner (R's of more than 0.80) by means of 'Agility Runs of short distance'. The Illinois Agility Run has been established by Cureton (27) to be a valid test of agility.

Nicks and Fleishman (28) indicate that shuttle runs and dodging runs load highly in the Speed of Change of Direction (in space) factor.

<u>Item 2</u> - 50 Yard Dash:- This measure of the ability to make successive movements with the legs (an index of running speed) is the factor used in the AAHPER Youth Fitness Test which thus signifies its accepted validity (29). The reliability of this item has been ascertained to be high (0.90 and above) by Larson and Yocom (30). They maintain that any of the runs from 30 yards to 100 yards may be used as an index of speed, however, the shorter distances are used for the less trained and the young and the longer distances for the older and trained individuals.

<u>Item 3</u> - Standing Broad Jump:- Explosive strength or power of the leg muscles is adequately evaluated by this item. Scott (31) has obtained a validity of 0.79 for this item. Larson and Yocom (32) rate the reliability of Standing Broad Jump in the high category (0.90 and above). This event frequently correlates above 0.60 with motor ability scores.

<u>Item 4</u> - Chins:- The dynamic strength and endurance of the arm flexor muscles are measured by this item which is of accepted validity as indicated by its use in the AAHPER Youth Fitness Test (33). Rogers (34) has established reliability ranging from 0.91 to 0.98.

<u>Item 5</u> - Dips:- This measure of the dynamic strength and endurance of the arm extension muscles has no scientific authenticity but it may be accepted on face validity. This item, used in the Larson Dynamic Strength Test (Men), along with chinning and vertical jump correlates 0.82 with the 15 item composite Motor Ability Criterion (35). The reliability of this item

has been ascertained to be 0.90 by Cureton (36) and in the high category (0.90 and above) by Larson and Yocom (37).

Nicks and Fleishman (38) state that chins and dips are the best tests of the Dynamic Strength Factor.

Item 6 - Right Hand Grip

Item 7 - Left Hand Grip Static Strength Dynamometer

Item 8 - Back Lift

Item 9 - Leg Lift

These dynamometrical measures of hand, back and leg strength were validated by Rogers as follows:

Item	Reliability	Validity With Athletic Index
Right Grip	0.92 - 0.98	0.68
Left Grip	0.90 - 0.97	0.68
Back Lift	0.88 - 0.97	0.66
Leg Lift	0.86 - 0.96	0.64

The summation of the raw scores of the four tests correlated 0.571 with the composite standard score criterion obtained by summing the standard scores of 22 physical fitness tests. The correlation is .555 when the same prediction is made by summing the four standard scores and 0.592 in multiple regression prediction (39).

Item 10 - Total Strength Per Pound of Body Weight:- This ratio correlates 0.517 with all-around motor fitness indices (40). Moderate correlation is obtained with overall ratings of physique (somatotype ratings). It is negatively correlated with fat.

Item 11 - Cureton Shoulder Extension

Item 12 - Cureton Trunk Extension

Item 13 - Cureton Trunk Flexion

Extent flexibility may be tested reliably (41) and validly (42) by the three Cureton Flexibility Items. These ratings are as follows:

Item	Reliability	Validity
Shoulder Extension	0.85	0.23 - 0.64
Trunk Extension	0.72	0.77 - 0.88
Trunk Flexion	0.96	0.29 - 0.64

Cureton (43) evaluates the major components of Motor Performance with these test items as follows:

Component I - Agility

Item 1 - Illinois Agility Run

Component II - Speed

Item 2 - 50 Yard Dash

Component III - Power

Item 3 - Standing Broad Jump

Component IV - Dynamic Strength and Muscular Endurance

Item 4 - Chins

Item 5 - Dips

Component V - Static Strength

Item 6 - Dynamometer - Right Hand Grip

Item 7 - Dynanometer - Left Hand Grip

Item 8 - Dynamometer - Back Lift

Item 9 - Dynamometer - Leg Lift

Item 10 - Total Strength Per Pound of Body Weight

Component VI - Extent Flexibility

Item 11 - Cureton Shoulder Extension

Item 12 - Cureton Trunk Extension

Item 13 - Cureton Trunk Flexion

Testing Personnel

Test administration was carried out by two graduate students at the University under the direction of the Research Professor of Physical Education. The Cameron Heartometer was operated exclusively by the Research Professor.

Administration of test items, manipulation of equipment, and organization of testing routine were all thoroughly accomplished prior to the actual testing of the experimental group.

Test Administration

The fifteen test measurements were administered during the first week and again during the final week of the term.

The tests were given in a definite sequence at specific times of the day. The same time and environmental conditions were used for both initial and final tests.

The tests were given in four groups. (See Appendix B). Group I tests were given during the second class period, while Groups II, III and IV were administered at three individual appointments during the first week. Similarly, for the final testing, Group I tests were given to the entire groupat the twenty-first class period with the other three Groups administered during the week of the twenty-second class.

The physical fitness tests were administered according to standardized procedures as follows:

Cameron Heartometer - Brachial Sphymograph:

The Heartometer was operated as directed in the Cameron Heartometer Corporation Pamphlet (44).

Illinois Agility Run:

The Illinois Agility Run is described fully by Cureton (45).

Five Minute Step Test:

The Step Test was administered by the two graduate students to two subjects at a time following the instructions given by Brouha (46).

AAHPER Fitness Test Items - 50 Yard Dash; Standing Broad Jump; Chins; 600 Yard Run-Walk:

These items were administered according to the directions given in the AAHPER Youth Fitness Test Manual (47).

Dips:

This test was administered according to the directions given in Mathews (48).

Dynamometrical Strength:

The two grip tests, back lift and leg lift were administered according to the specifications of Cureton (49).

Cureton Flexibility Tests:

These items were administered according to the directions given by Cureton (50).

Statistical Analysis: In order to determine whether or not the sample selected could be considered representative of male freshmen in the University's Required Programme, a comparison was made between the experimental group and the 1962 University of British Columbia AAHPER Fitness Test Sample. Criteria for comparison were height, weight, and performance in Chins, Standing Broad Jump, 50 Yard Dash and 600 Yard Run-Walk.

The statistical technique outlined by Walker and Lev (51) was used to estimate sampling error in order to determine the probability that the deviation of means of the test sample from the University sample arose solely from sampling error.

$$Z = \frac{\sqrt{N_E}\,(M_p - M_E)}{SD_p}$$

Mp	-	Population (U.B.C. AAHPER) mean
M_E	-	Experimental sample mean
SDp	-	Standard Deviation of the population
N_E	-	Number in Experimental sample
Z	-	Z score obtained for variable
2a	-	area outside two ordinates of Z (probability that difference between means could have occurred due to chance)
2a	-	acceptable at minimum of 0.05 for accepting null hypothesis.

The arguments of Nelson and Hurst (53) were followed in setting a level of confidence of 0.05 for determining the reliability of the difference between the groups. Since there was no reason to believe that the sample should be different from the main body of freshment, a lower level of confidence than 0.05 would increase the probability of Type I error, i.e., of rejecting a true hypothesis of no difference between groups. A decrease in the probability of accepting a false hypothesis of no difference on Type II error was not considered as important as the necessity to guard against rejecting a hypothesis of no difference between groups.

Physical fitness progress made during the circuit training programme was evaluated by determining the significance of the differences in performance on initial and final tests.

The statistical method used was the 'Difference Method'. Garrett (52) states, "When groups are small the difference method is often to be preferred ...." This method determines the significance of the mean of the differences between initial and final performances.

M_D - Mean of difference between initial and final tests

SD_D - Standard Deviation of differences

SE_D - Standard Error of mean of differences

t - $\dfrac{M_D - 0}{SE_{MD}}$ (acceptable at the 5 percent level of confidence)

df - Degrees of freedom

N-1 - Number in sample minus one

The test of the null-hypothesis used was a one-tail test with an arbitrarily chosen (0.05) level of significance.

A second technique was employed to evaluate the class progress. This involved the conversion of raw mean scores and mean differences to Standard Scores. Performance of the experimental group in Chins, Standing Broad Jump, 50 Yard Run, and 600 Yard Run-Walk was related to that of male college freshmen at the University according to norms established in the 1962 University of British Columbia AAHPER Fitness Study (54). Scores in all other test items were related to Standard Score Tables established for normal young men of ages 18-25 years at the University of Illinois (55).

This comparison was made in order to know if the results were worthwhile biologically.

It was felt that although some of the gains may not have been significant statistically, due to large Standard Errors of mean differences, this gain may have been significant in a practical sense. For purposes of description, improvements in Standard Scores were classified arbitrarily as follows:

Standard Score Gain	Classification
Over 15	Very Good
10 - 14	Good
5 - 10	Fair
Under 5	Low

Finally, the percent of students whose scores increased, remained the same or decreased after ten weeks of participation in the circuit training programme, was determined and tabled.

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CHAPTER V

RESULTS AND DISCUSSION

Introduction: Twenty male freshmen students enrolled in the Physical Education Required Programme Circuit Training Class, completed a battery of physical fitness tests to determine motor performance and cardiovascular condition. This experimental group, with mean age, height and weight being respectively, 18.9 years, 71 inches and 157.3 pounds, then participated in a ten week programme of specialized exercise known as 'circuit training'. Five subjects withdrew from the class and thus from the experimental group. During the final week, after twenty periods of circuit training, the fifteen remaining subjects repeated the original battery of tests.

The statistical treatment of the results consisted of an analysis of the reliability of the difference between means for each test item, a conversion of the mean test scores into standard scores from scoring tables for normal young college men in order to determine mean standard score improvement, and an analysis of the number of students who, between tests, increased their scores, decreased their scores or remained the same.

Since the sample was selected at random and no attempt was made to control the characteristics of the sample, a comparison was made with the 1962 University of British Columbia AAHPER Youth Fitness Test Sample. The criteria for comparison was: height, weight and performance in Chins, Standing Broad Jump, 50 Yard Dash and 600 Yard Run-Walk.

In order to determine the effects of other environmental variables which might have influenced the level of fitness of the test sample a Health-

Habit Questionnaire was given to each subject both at the initial and final tests. This was an attempt to determine any changes in personal and health habits which might have markedly influenced the physical fitness of the subjects. Habits evaluated were nutrition, rest, exercise and smoking.

Presentation of Results: The statistical results are presented in Tables with accompanying discussion. The main sections are:

A. Comparison between the Circuit Training Sample and the University of British Columbia Freshman Population (using height, weight and several motor fitness variables).

B. Results of Health-Habit Questionnaire.

C. Cardiovascular Test Results.

D. Motor Performance Test Results.

E. Summary of Changes in Cardiovascular Condition and Motor Performance.

F. Comparison Between the Circuit Training and Physical Conditioning Programmes.

For each component of Cardiovascular Condition and Motor Performance, three Tables are included. The first containing statistical results; the second, indicating initial and final means and the differences between means expressed in Standard Scores; the third, showing the number of students whose scores increased, the number whose scores did not increase and those who obtained lower scores from initial to final tests. In the latter case, the terms 'increased' and 'decreased' refer to quantitative changes in performance.

Individual raw scores are reported in Appendices G to J.

A. Comparison Between the Circuit Training Sample and the Freshman (Required Programme) Population

In the manner described by Walker and Lev (1), a comparison of means was made between the circuit training sample and the youth fitness test group in relation height and weight and motor performance in Chins (Dynamic Muscular Strength and Endurance), Standing Broad Jump (Explosive Strength), 50 Yard Dash (Speed), and the 600 Yard Run-Walk (Endurance in Short Hard Work).

A two-tailed test (level of confidence 0.05) was used and any Z values falling outside the critical region would result in rejecting the hypothesis of no difference between experimental and youth fitness group means.

Table 2 shows that in no variable considered was the difference between these two groups sufficiently large as to cast doubt on the proposition that the experimental sample could have arisen by random sampling from the male freshman population. Thus it was reasonable to conclude that bias was not introduced into the experiment by selection of typical students and that other groups of students could be influenced in the same manner by the same exercise programme used in this study.

B. Health - Habit Questionnaire Results

Analysis of pre and post-training questionnaire responses furnished both descriptive information as to the nature of the subjects and an estimate of any changes in personal habits which might have, positively or negatively

TABLE 2

RELIABILITY OF DIFFERENCE BETWEEN EXPERIMENTAL AND YOUTH FITNESS GROUP MEANS

Variable	My	M_E	D_M	SDy	Z	a	Acpt./Rej. Null Hypo.
Height (ins.)	70.50	71.00	0.50	2.70	0.72	.47	Accept
Weight (lbs.)	154.80	157.30	2.50	19.20	0.50	.50	Accept
Chins (no.)	7.30	6.13	1.17	2.80	1.62	.11	Accept
Standing Broad Jump (ins.)	87.10	89.60	2.50	8.00	1.21	.22	Accept
50 Yards Dash (secs.)	6.85	6.92	0.07	0.39	0.69	.48	Accept
600 Yards Run (secs.)	104.70	107.80	3.10	9.68	1.24	.21	Accept

Level of confidence = 0.05 (for 'a' smaller than 0.05 reject null hypothesis)

My Youth Fitness Group Mean

M_E Experimental Sample Mean

D_M Difference Between Means

SDy Standard Deviation of Youth Fitness Group

Z 'Z' score obtained

a Area outside two ordinates of Z

affected physical fitness.

At the initial test session, subjects were asked to subjectively rate their level of fitness. Three subjects rated themselves as being in good condition, ten felt they were in fair condition, and two thought their fitness level was poor.

In the over-all analysis, five subjects indicated that they experienced colds during the initial testing session. Two subjects reported the same problem during the final test period. Thirteen subjects were non smokers, one smoked less than five cigarettes and one smoked twenty-five or more cigarettes a day. No change was reported in smoking habits during the experimental period. The average sleep per night reported was approximately 7.2 hours. No meaningful changes were reported in sleeping habits. Similarly, no meaningful changes in eating habits were noted. Five subjects indicated that they had part-time jobs on the week-ends. However, no changes were reported in either duration or working hours or schedules.

Seven students stated that prior to the first term, they had engaged in regular vigorous exercise or moderate-hard manual work. Four of these subjects indicated eight hours per day while the other three stated five, two and one hours per day.

Answers to the questionnaire showed that no students were engaged in any regular physical exercise or activity or hard manual work additional to the physical conditioning class in which they were enrolled.

In physical education experimental studies there are many uncontrolled factors which might influence fitness. At best, test subjects should continue to lead normal lives. It is impossible, however, to completely control personal habits which may have some effect on fitness.

C. Cardiovascular Test Results

Component I - Stroke Volume:

Changes in test items measuring Stroke Volume were as follows:

Area Under Curve: The statistically significant mean improvement of 0.05 sq. cms. equals a 7 standard score gain from an original level of 43 standard scores. Eleven subjects showed positive changes while only three scored below their initial level after participating in the programme. One subject did not change his score.

Cureton, in reporting his experience with brachial pulse wave tracings at the University of Illinois (2), has stated that the pulse wave increases with progressive training, especially the area. The present results tend to agree with this finding.

The three subjects (numbers 12, 14 and 15) who had decreased scores at retest also made fewer positive changes in all cardiovascular measurements than the rest of the group.

Systolic Amplitude (Sitting): The positive difference of 0.02 cms. was not statistically significant, and represents a gain of 1 standard score from an initial mean level of 40 standard scores. Seven subjects showed

TABLE 3

RELIABILITY OF MEAN DIFFERENCES BETWEEN

INITIAL AND FINAL SCORES

STROKE VOLUME (BLOOD EJECTION VELOCITY)

Brachial Pulse Wave Variables	M_i	M_f	M_D	SD_D	SE_{MD}	t	Acept./Rej. Null Hypo.
Area Under Curve (sq. cms.)	0.25	0.30	0.05	0.07	0.02	2.50	Reject
Systolic Amplitude Sitting (cms.)	0.98	1.00	0.02	0.26	0.07	0.30	Accept
Systolic Amplitude Standing (cms.)	0.66	0.73	0.07	0.16	0.04	1.75	Accept
Systolic Amplitude After Exercise (cms.)	1.18	1.29	0.11	0.23	0.06	1.83	Reject
Diastolic Amplitude (cms.)	0.46	0.50	0.04	0.12	0.03	1.33	Accept
Dicrotic Notch Amplitude (cms.)	0.44	0.52	0.08	0.14	0.04	2.00	Reject
Obliquity Angle (degrees)	23.24	22.72	-0.52	2.00	0.52	1.00	Accept
Diastolic Time (seconds)	0.43	0.53	0.10	0.13	0.03	3.33	Reject
Systolic Time (seconds)	0.24	0.23	-0.01	0.02	0.01	1.00	Accept
Rest/Work Ratio	1.80	2.29	0.49	0.69	0.18	2.72	Reject

TABLE 4

STANDARD SCORES FOR STROKE VOLUME

(BLOOD EJECTION VELOCITY)

Brachial Pulse Wave Variables	Initial Mean	Final Mean	Difference	Improvement Rating
Area Under Curve	43	50	7	Fair
Systolic Amplitude Sitting	40	41	1	Low
Systolic Amplitude Standing				
Systolic Amplitude After Exercise				
Diastolic Amplitude	45	50	5	Fair
Dicrotic Notch Amplitude	52	60	8	Fair-Good
Obliquity Angle	52	58	6	Fair
Diastolic Time				
Systolic Time				
Rest/Work Ratio	48	62	14	Very Good

TABLE 5

CARDIOVASCULAR COMPONENT I - POSITIVE

CHANGES, NO CHANGES AND REGRESSIONS

Brachial Pulse Wave Variables	Positive Changes	No Changes	Regressions
Area Under Curve	11	1	3
Systolic Amplitude Sitting	7	0	8
Systolic Amplitude Standing	10	0	5
Systolic Amplitude After Exercise	10	0	5
Diastolic Amplitude	10	0	5
Dicrotic Notch Amplitude	10	0	5
Obliquity Angle	9	0	6
Diastolic Time	12	1	2
Systolic Time	7	4	4
Rest/Work Ratio	12	0	3

increases while eight regressed in this item.

Both Cureton (3) and Henry (4) feel that the systolic measurement serves more to distinguish athletes from non-athletes rather than as a measure of improvement in cardiovascular fitness. By implication it would seem that only persistant training over several years would produce important changes in this variable. That the present findings seem to agree with this hypothesis is indicated firstly, by the non-significance of the experimental results, secondly, by the 'sedentary subject' standard score level of 40 standard scores and thirdly, by the fact that this group of freshmen is not athletically inclined.

Systolic Amplitude (Standing): The positive difference of 0.07 cms. was just less than that necessary for statistical significance. Ten subjects increased their scores in this item while five regressed. Since no standard scores were available for this item, scores could not be compared with norms completed on other young men. The mean difference represents a 10.6 percent gain.

This measurement which was considered to reflect autonomic nervous regulation of the hydrostatic mechanisms involved in maintaining orthograde blood pressure and stroke volume, has not been used in many training studies and it is uncertain whether or not expectancy for change in this item as a result of training is any greater than that for sitting systolic amplitude (5).

Systolic Amplitude (After Exercise): A statistically significant mean gain of 0.11 cms. was obtained in this item. This represents an improvement of 9.2 percent of the initial mean. Ten subjects recorded increased amplitudes ranging from 0.02 cms. to 0.37 cms. while five subjects had reduced amplitudes ranging from 0.02 cms. to 0.26 cms.

This measurement is considered proportional to stroke volume adjustment immediately following a standard light exercise. Amplitude of the wave immediately following exercise is considered a more important measurement of cardiovascular condition than other measurements taken in the resting state.

Diastolic Amplitude: The mean positive difference of 0.04 cms. was not statistically significant, and represents a gain of 5 standard scores, from an initial mean level of 45 standard scores. Ten subjects showed increased scores while five regressed in this item.

Dicrotic Notch Amplitude: A statistically significant mean gain of 0.08 cms. was obtained. This represents a standard score increase of 8, from a pre-training level of 52 standard scores. Positive changes, in terms of increased amplitude were recorded for ten subjects and three regressed (among them subjects 10, 12, 14 and 15).

Cureton (6) states that fatigue of the autonomic nervous system and smooth musculature of the aortic arch seems a reasonable explanation as to why the dicrotic notch is lowered, but that dilation of the arterioles and capillaries may be a greater causal factor.

Obliquity Angle: The mean difference of -0.52 degrees was in the direction of increased fitness but was not statistically significant and represents a gain of 6 standard scores from an initial mean level of 52 standard scores. Nine subjects increased their scores and six had lower measurements on retesting. Decrease in the size of the angle is interpreted as beneficial in training studies - reflecting increased rate of change of pressure due to stronger ventricular contraction.

A slow acting heart muscle, due to weakness or to sluggish heart tissue, gives a greater angle because more time is taken for the upward systolic stroke to the maximum point. In such a case it is inferred that the heart muscle has difficulty overcoming the resistance of the blood column above the semilunar valves or that there is internal resistance in the heart tissue itself.

Time of Diastole: A statistically significant mean improvement of 0.10 cms. was noted in this item. This represents an improvement of 23.2 percent of the initial mean, which is a large gain. Twelve subjects increased their initial scores, two regressed and one did not change.

Time of Systole: The sample showed a mean change of only 4.2 percent of the initial mean, which is a very small gain. A decrease in systolic time was considered an improvement in cardiovascular condition. Seven subjects showed an increase, four regressed and four did not change. The mean gain was not significant statistically.

Failure to show a signficant difference between means in this item is in line with the experience of Cureton at the University of Illinois with groups of men undergoing training (7). Systolic time in the cardiac cycle is relatively fixed and not related to changes in the autonomic nervous system attributable to training or detraining.

Rest/Work Ratio: The statistically significant mean improvement of 0.49 units represents a standard score increase of 14 from an initial mean level of 48 standard scores. Twelve subjects increased their scores and three regressed.

This measurement is a ratio of the diastolic time to the systolic time and changes in this ratio will mainly reflect changes in diastolic time. It is a useful measure of the relative relaxation phase of the heart cycle which in athletes is much greater than in non-athletes and much greater in the trained than the untrained. A strong efficient cardiovascular system has a high ratio of 4 to 1; an average cardiovascular system is 1.89 to 1; a poor cardiovascular system is lower than 1.21 to 1. Both Carlile (8) and Yarr (9) have shown that the rest/work ratio improves significantly with systematic training.

The three items which were shown in the Cureton and Sterling study to have highest factor loadings on Stroke Volume (sitting systolic amplitude, 0.69; standing systolic amplitude, 0.66; and diastolic amplitude, 0.63) did not show significant mean changes in this study. On the other hand, those items with lower factor loadings (area under curve, 0.50; and dicrotic notch amplitude, 0.31) did show statistically significant mean changes. However, Henry (10) mentions that it is quite possible that young subjects or subjects who were in poor physical condition prior to training might exhibit a different pattern of physiological changes than the athletically inclined. The type of training could also influence the results.

Component VI - Endurance in Short Hard Work:

TABLE 6

RELIABILITY OF MEAN DIFFERENCES BETWEEN

INITIAL AND FINAL SCORES

ENDURANCE IN SHORT HARD WORK

Variable	M_i	M_f	M_D	SD_D	SE_{MD}	t	Acept./Rej. Null Hypo.
600 Yard Run-Walk (seconds)	107.80	106.30	-1.50	3.09	0.80	1.87	Reject

TABLE 7

STANDARD SCORES FOR ENDURANCE

IN SHORT HARD WORK

Variable	Initial Mean	Final Mean	Difference	Improvement Rating
600 Yard Run-Walk	55	58	3	Low

TABLE 8

CARDIOVASCULAR COMPONENT VI - POSITIVE

CHANGES, NO CHANGES AND REGRESSIONS

Variable	Positive Changes	No Changes	Regressed
600 Yard Run-Walk	12	1	2

Changes in the test item measuring Endurance In Short Hard Work was as follows:

600 Yard Run-Walk: A statistically significant mean gain of 1.50 seconds was obtained. This represents a standard score increase of 3, from a pre-training level of 55 standard scores. Twelve subjects increased their scores while only two regressed and one remained the same. All of the positive changes except one were less than 4 seconds .

The 600 yards run was the only test of Endurance In Short Hard Work administered in this study. The small mean change of 1.5 seconds from test to retest, though statistically significant, was practically (biologically) unimportant.

In a study by Watt (11), seventeen subjects went through a developmental course in which circuit training was used. He concluded that improvement in the performance of the cardiorespiratory test (300 yard run) can be increased significantly by circuit training. Nünney (12) found that combined circuit training and swimming significantly improved swimming speed over 33 1/3 yard.

Brown (13) found that a physical education programme for fifth grade girls which included a 10 minute circuit training programme made a statistically significant mean improvement of 5.08 seconds (0.05 percent level of confidence).

Component VII - Vagus Tone:

TABLE 9

RELIABILITY OF MEAN DIFFERENCES BETWEEN

INITIAL AND FINAL SCORES

VAGUS TONE

Variable	M_i	M_f	M_D	SD_D	SE_{MD}	t	Acept./Rej. Null Hypo.
Pulse Rate Sitting (beats/min.)	82.50	71.00	-11.50	14.04	3.62	3.18	Reject
Five Minute Step Test (beats)	184.20	179.80	-4.40	6.72	1.74	2.53	Reject

TABLE 10

STANDARD SCORES FOR VAGUS TONE

Variable	Initial Mean	Final Mean	Difference	Improvement Rating
Pulse Rate Sitting	45	60	15	Very Good
Five Minute Step Test	42	47	5	Fair

TABLE 11

CARDIOVASCULAR COMPONENT VII - POSITIVE

CHANGES, NO CHANGES AND REGRESSIONS

Variable	Positive Changes	No Changes	Regressed
Pulse Rate Sitting	11	0	4
Five Minute Step Test	10	0	5

Changes in the test items measuring Vagus Tone were as follows:

Pulse Rate: The statistically significant mean decrease in resting pulse rate of 11.50 beats per minute equals a 15 standard score gain from an original level of 45 standard scores. Eleven subjects showed increased scores in this item and four regressed (among them subjects 12, 13 and 14).

Improvement in mean sitting pulse rate (45 s.s. to 60 s.s.) was the largest of any made in the cardiovascular measures used in this study.

Since the classical study of the Cambridge oarsmen there have been numerous reports showing that athletic training reduces resting pulse rate (14). Many studies have found low validity for resting heart rate as a test of performance, as for example the investigation of Massey et al (15). The cause of failure is due to the fact that such studies have typically used a performance criterion, and the pulse rate is not a valid test of performance. It does, however, have validity as an indirect measure of athletic conditioning ($r = 0.758$). According to Henry (16) sitting pulse rate is probably a better test for this purpose than any performance test.

Cureton and Sterling (See Appendix F) reported the pulse rate to have a factor loading of -0.467 with stroke volume. This suggests that resting pulse rate is negatively correlated with systolic amplitude of the brachial pulse wave. In this study, however, change in mean resting pulse rate was statistically significant but the mean test-retest difference in sitting systolic amplitude was not statistically significant. Heart rate seems a more effective variable for showing changes in athletic condition, than : pulse wave amplitude.

Five Minute Step Test: A statistically significant mean improvement of 4.40 recovery beats was obtained. This represents a standard score increase of 5 from a pre-training level of 42 standard scores. Ten subjects showed increased scores while five regressed (among them subjects 12, 14 and 15).

The mean total pulse recovery count showed a statistically significant change from 184.2 beats (42 s.s.) to 179.8 beats (47 S.S.). Five subjects had lower scores at retest ranging from 10 to 16 beats. Five had increased recovery counts of from 1 to 5 beats and the remaining five had reduced counts of from 1 to 6 beats. Only the first five subjects could be considered to have made practically (biologically) important changes in recovery pulse count. Even so there was a very large difference between retest recovery pulse counts of these men and those of trained endurance athletes (17).

Howell et al (18) found that an identical circuit training programme as used in this study but over only a four week period, caused a statistically significant improvement (t = 4.94) in the modified Harvard Step Test with an experimental group of freshmen students. A control group, participating in a service programme consisting of volleyball and badminton over a four week period twice a week for 30 minutes, showed no statistically significant gains in the modified Harvard Step Test (t = 1.56).

Component VIII - Splanchnic Ptosis:

TABLE 12

RELIABILITY OF MEAN DIFFERENCES BETWEEN

INITIAL AND FINAL SCORES

SPLANCHNIC PTOSIS

Brachial Pulse Wave Variables	M_i	M_f	M_D	SD_D	SE_{MD}	t	Acept./Rej. Null Hypo.
Area Under Curve (sq. cms.)	0.25	0.30	0.05	0.07	0.02	2.50	Reject
Systolic Amplitude Sit. - Stand. (cms.)	0.26	0.32	0.06	0.13	0.03	2.00	Reject

TABLE 13

STANDARD SCORES FOR SPLANCHNIC PTOSIS

Variable	Initial Mean	Final Mean	Difference	Improvement Rating
Area Under Curve	43	50	7	Fair
Systolic Amplitude Sit. Stand.				

TABLE 14

CARDIOVASCULAR COMPONENT VIII - POSITIVE

CHANGES, NO CHANGES AND REGRESSIONS

Variable	Positive Changes	No Changes	Regressed
Area Under Curve	11	1	3
Systolic Amplitude Sit. - Stand.	11	1	3

Five measurements of the brachial pulse wave were considered measurements of the factor - Splanchnic Ptosis. Only two gave results which were statistically significant at the 0.05 level of confidence. The mean changes in four of these five variables were discussed under factor - Stroke Volume. These variables have loadings under both factors.

The area under curve (factor loading of 0.50 with Stroke Volume) has a similar factor loading of 0.52 with Splanchnic Ptosis whereas the systolic amplitude and the diastolic amplitude (factor loadings of 0.68 and 0.63 with Stroke Volume) have only factor loadings of 0.33 and 0.46 with Splanchnic Ptosis. The dicrotic notch amplitude has factor loadings of 0.31 and 0.36 with Stroke Volume and Splanchnic Ptosis respectively. Systolic amplitude (difference between sitting and standing amplitudes) has a factor loading of 0.76 with Splanchnic Ptosis.

Changes in this test item were as follows:

Systolic Amplitude (Sitting-Standing): A statistically significant mean gain of 0.06 cms. was obtained for this item. This represents an improvement of 23 percent of the initial mean which is a large improvement. Eleven subjects increased their scores while three regressed and one remained the same.

The measurements for this variable are in agreement with those of Massey et al (19), that is, the systolic amplitude decreases as the subject changes from sitting to standing. The interpretation of these changes in ratio or 'difference' scores is difficult due to the effect on derived scores of error in each of the two related measurements.

There were numerous individual differences in the patterns of changes made by subjects from test to retest in the cardiovascular test items. Cardiovascular condition seemingly improved in all but one of the test items for subject 4. Subjects 5 and 13 showed positive changes in thirteen items and subject 2, in twelve items. Seven students increased their scores in ten to eleven items and one, in only half the items. Subjects 12, 14 and 15 gave positive changes in only two, five and four items respectively and thus did not appear to have improved in cardiovascular fitness during the training period.

Subjects 12, 14 and 15 were three of the four who had increased resting pulse rates on retest. It is fairly easy to demonstrate reductions in the resting pulse rate of normal subjects through regular endurance training. If a subject is fatigued there may be no apparent reduction in pulse rate and it may even increase. These three subjects were the only ones who showed decreased area under the curve on retest thus indicating low energy cardiovascular systems. These same three were among the five subjects who on retest had increased recovery counts after five minutes of bench stepping. The results seem to reflect fatigue of the autonomic nervous system to which circuit training might even have been contributory.

Application of the information from the Health - Habit Questionnaire to the above results furnished some possible explanations of these phenomena. Subjects 12, 14 and 15 were three of the five students who held part-time jobs (eight to twelve hours) on the week-ends. Perhaps two periods of circuit training a week coupled with their part-time job was too much of a strain on their body systems. Subject 14 also suffered from a series of colds throughout the whole term.

Subject 4, who gave increased scores in all but one item, not only had a part-time job on the week-ends but also had worked eight hours a day during the summer at hard manual labor. The circuit programmes seems to have acted as a further training stimulus since his initial test results were only average. Subject 13, one of the two who gave positive changes in all items but two, worked seven hours a day during the summer and also suffered from a slight cold during the initial test. Both factors may have influenced his final results positively. Subject 2, who gave increased scores in twelve items suffered a severe cold during the first two weeks of the term.

D. Motor Performance Test Results Component I - Agility (Illinois Agility Run Test)

TABLE 15

RELIABILITY OF MEAN DIFFERENCES BETWEEN

INITIAL AND FINAL SCORES

AGILITY ITEM

Variable	M_i	M_f	M_D	SD_D	SE_{MD}	t	Acept./Rej. Null Hypo.
Illinois Agility Run (seconds)	18.48	18.11	-0.37	0.45	0.12	3.08	Reject

TABLE 16

STANDARD SCORES FOR AGILITY ITEM

Variable	Initial Mean	Final Mean	Difference	Improvement Rating
Illinois Agility Run	64	69	5	Fair

TABLE 17

MOTOR FITNESS COMPONENT I - POSITIVE

CHANGES, NO CHANGES AND REGRESSIONS

Variable	Positive Changes	No Changes	Regressed
Illinois Agility Run	12	0	3

The mean improvement in agility running time of 0.37 seconds represents a standard score improvement of 5 from an initial mean level of 64 standard scores. Although the improvement was small (5 s.s.) in a biological sense, it was statistically significant because of the small Standard Error between means (0.12).

Twelve subjects recorded better performance times ranging from 0.10 seconds to 1.20 seconds. Nine subjects showed times equal to or better than 0.40 seconds. In comparison with other motor fitness item mean scores, the group had a relatively high initial score (64 s.s.) in the Agility Run.

Component II - Speed (50 Yard Dash)

TABLE 18

RELIABILITY OF MEAN DIFFERENCES BETWEEN

INITIAL AND FINAL SCORES

SPEED ITEM

Variable	M_i	M_f	M_D	SD_D	SE_{MD}	t	Acept./Rej. Null Hypo.
50 Yrd. Dash (secs.)	6.92	6.69	-0.23	0.26	0.07	3.28	Reject

TABLE 19

STANDARD SCORES FOR SPEED ITEM

Variable	Initial Mean	Final Mean	Difference	Improvement Rating
50 Yard Dash	46	52	6	Fair

TABLE 20

MOTOR FITNESS COMPONENT II - POSITIVE

CHANGES, NO CHANGES AND REGRESSIONS

Variable	Positive Changes	No Changes	Regressed
50 Yard Dash	12	0	3

A statistically significant mean improvement of 0.23 seconds equals a standard score gain of 6 from an initial level of 46 standard scores. Twelve subjects bettered their initial scores while three regressed. The greatest positive difference was 0.06 of a second.

In comparison with other motor fitness item mean scores, the group had a relatively low initial score (46 s.s.) in the 50 Yard Dash.

Component III - Explosive Strength (Standing Broad Jump Test)

TABLE 21

RELIABILITY OF MEAN DIFFERENCES BETWEEN

INITIAL AND FINAL SCORES

EXPLOSIVE STRENGTH ITEM

Variable	M_i	M_f	M_D	SD_D	SE_{MD}	t	Acept./Rej. Null Hypo.
Standing Broad Jump (inches)	89.3	91.8	2.5	1.68	0.43	5.81	Reject

TABLE 22

STANDARD SCORES FOR EXPLOSIVE STRENGTH ITEM

Variable	Initial Mean	Final Mean	Difference	Improvement Rating
Standing Broad Jump	54	61	7	Fair

TABLE 23

MOTOR FITNESS COMPONENT III - POSITIVE

CHANGES, NO CHANGES AND REGRESSIONS

Variable	Positive Changes	No Changes	Regressed
Standing Broad Jump	15	0	0

A statistically significant mean gain of 2.5 inches was obtained. This represents an improvement of 7 standard scores, from an initial mean level of 54 standard scores. All of the subjects in the experimental group showed positive changes in this item. The two largest changes were six inches and seven inches while the remaining thirteen subjects showed positive changes of three inches or less.

Except for the two largest positive changes, all changes were reasonably similar in amount and it is reasonable to assume that a general improvement in jumping power did occur.

It was seen that low to fair improvements were made in the three test items utilizing the Explosive Strength of the legs; the Agility Run, 50 Yard Dash and Standing Broad Jump. Ten subjects showed better scores in all three items and four subjects gave positive changes in two items indicating a general consistent pattern of improvement in tests measuring aspects of Explosive Strength or Power.

Component IV - Dynamic Strength and Muscular Endurance (Chins and Dips Tests)

TABLE 24

RELIABILITY OF MEAN DIFFERENCES BETWEEN

INITIAL AND FINAL SCORES

DYNAMIC STRENGTH AND MUSCULAR ENDURANCE ITEM

Variable	M_i	M_f	M_D	SD_D	SE_{MD}	t	Acept./Rej. Null Hypo.
Chins (no.)	6.13	7.50	1.37	0.79	0.20	6.85	Reject
Dips (no.)	11.73	14.86	3.13	3.62	0.94	3.33	Reject

TABLE 25

STANDARD SCORES FOR DYNAMIC STRENGTH

AND MUSCULAR ENDURANCE ITEM

Variable	Initial Mean	Final Mean	Difference	Improvement Rating
Chins	51	58	7	Fair
Dips	53	64	11	Good

TABLE 26

MOTOR FITNESS COMPONENT IV - POSITIVE

CHANGES, NO CHANGES AND REGRESSIONS

Variable	Positive Changes	No Changes	Regressed
Chins	14	0	1
Dips	11	2	2

Changes in test items measuring Dynamic Strength and Muscular Endurance were as follows.

Chins: The statistically significant mean improvement of 1.37 chins equals a standard score gain of 7 from an initial level of 51 standard scores. Fourteen subjects gave positive changes while one regressed. The increased scores ranged from one-half chin to three chins while the one reduced score was one-half chin.

These results compare favorably with those of Brown (20) whose experimental group after ten weeks of circuit training improved by 1.22 chins representing a standard score improvement of 6.

Dips: The mean improvement of 3.13 dips equals a standard score gain of 11 from an initial level of 53 standard scores. Eleven subjects bettered their initial scores, two failed to change and two regressed. The increased scores ranged from one dip to eleven dips.

There was no apparent relationship among individuals between improvement or regression in Chins and improvement or regression in Dips.

Component V - Static Strength (Dynamometrical Tests)

TABLE 27

RELIABILITY OF MEAN DIFFERENCES BETWEEN

INITIAL AND FINAL SCORES

STATIC STRENGTH ITEMS

Variable	M_i	M_f	M_D	SD_D	SE_{MD}	t	Acept./Rej. Null Hypo.
Right Grip	121.27	127.07	5.80	9.62	2.49	2.33	Reject
Left Grip	110.26	117.13	6.87	9.23	2.38	2.84	Reject
Back Lift	359.33	374.60	15.27	24.29	6.28	2.43	Reject
Leg Lift	474.27	557.73	83.46	73.32	18.95	4.40	Reject
Strength/Wgt.	6.75	7.50	0.75	0.42	0.11	6.82	Reject

TABLE 28

STANDARD SCORES FOR STATIC STRENGTH ITEMS

Variable	Initial Mean	Final Mean	Difference	Improvement Rating
Right Grip	53	58	5	Fair
Left Grip	53	60	7	Fair
Back Lift	60	64	4	Low
Leg Lift	68	83	15	Very Good
Strength/Wgt.	65	78	13	Very Good

TABLE 29

MOTOR FITNESS COMPONENT V - POSITIVE

CHANGES, NO CHANGES AND REGRESSIONS

Variable	Positive Changes	No Changes	Regressed
Right Grip	11	0	4
Left Grip	12	0	3
Back Lift	11	0	4
Leg Lift	14	0	1
Strength/Wgt.	14	0	1

Changes in test items measuring Static Strength were as follows:

Right Grip: The mean gain in this item of 5.80 pounds represents a 5 standard score increase from an initial mean level of 53 standard scores. Eleven subjects showed increased scores while four showed decreased scores.

Left Grip: The mean improvement of 6.87 pounds in this item equals an increase of 7 standard scores from an initial mean of 53 standard scores. Twelve subjects made positive changes while three showed a decrease in scores. Seven subjects increased their scores by 10 pounds or more (range 10 to 30 pounds).

Back Lift: A statistically significant mean gain of 15.27 pounds was obtained in this test item. This represents an improvement of 4 standard scores from an initial level of 60 standard scores. Eleven subjects had increased scores ranging from three pounds to fifty-five pounds. Five of these subjects showed positive changes above twenty-five pounds.

Leg Lift: The mean gain in this item of 83.46 pounds represents a 15 standard score increase from an initial mean level of 68 standard scores. All but one of the subjects recorded improved leg strength scores in the final performance. The greatest score increase by one subject was two hundred and thirty-eight pounds, with the subject recording five hundred pounds in the initial test and seven hundred and thirty-eight in the final test. Recalculation of results with this subject's score removed made little appreciable difference to the size of the 't' statistics. Four other subjects increased scores above one hundred pounds.

In view of the initial high level of strength in this item, the mean increase obtained represents a good improvement. A significant improvement was also obtained in the Agility Run, 50 Yard Dash and the Standing Broad Jump, which are all dependent upon leg strength.

Dynamometrical strength items showed improvements ranging from 4 standard scores in the Back Lift to 15 standard scores in the Leg Lift which would seem to indicate that the circuit training exercises had considerable effect on leg muscles.

Positive changes, no changes and regressions were found to be in the ration of 48:0:12 for all four items.

Strength Per Pound of Body Weight: A statistically significant mean improvement of 0.75 was obtained in this item. This represents an improvement of 11.1 percent of the initial mean which is a 'fair' gain. Fourteen subjects increased their scores while one regressed. Two subjects made positive changes above 1.40 while three others increased their ratios above 1.00.

Component VI - Extent Flexibility (Cureton Flexibility Tests)

TABLE 30

RELIABILITY OF MEAN DIFFERENCES BETWEEN
INITIAL AND FINAL SCORES
EXTENT FLEXIBILITY ITEMS

Variable	M_i	M_f	M_D	SD_D	SE_{MD}	t	Acept./Rej. Null Hypo.
Shoulder Extension (ins.)	9.09	11.45	2.36	2.57	0.66	3.58	Reject
Trunk Extension (ins.)	15.77	18.62	2.85	3.79	0.98	2.91	Reject
Trunk Flexion (ins.)	12.43	10.46	-1.97	2.11	0.55	3.08	Reject

TABLE 31

STANDARD SCORES FOR EXTENT FLEXIBILITY ITEMS

Variable	Initial Mean	Final Mean	Difference	Improvement Rating
Shoulder Extension	45	55	10	Good
Trunk Extension	61	70	9	Good
Trunk Flexion	53	60	7	Fair

TABLE 32

MOTOR FITNESS COMPONENT VI - POSITIVE

CHANGES, NO CHANGES AND REGRESSIONS

Variable	Positive Changes	No Changes	Regressions
Shoulder Extension	13	0	2
Trunk Extension	11	0	4
Trunk Flexion	13	0	2

Changes in test items measuring Extent Flexibility were as follows:

Shoulder Extension: The mean improvement of 2.36 inches represents a gain of 10 standard scores from an initial mean level of 45 standard scores. Thirteen subjects increased their scores and two regressed. The increased scores ranged from 0.40 inches to 8.10 inches with five of these subjects making positive changes of more than 3 inches.

The general consistent improvement in this item represents a substantial gain in Shoulder Flexibility during the experimental period.

Trunk Extension Backward: The mean improvement in this item was 2.85 inches or 9 standard scores from an initial level of 61 standard scores. Eleven subjects increased their initial scores, six of these by 4 or more inches. Four subjects regressed.

Trunk Extension Backward was apparently improved substantially by the circuit programme.

Trunk Flexion Forward: A mean improvement of 1.97 inches represents a gain of 7 standard scores from an initial mean level of 53 standard scores. Thirteen subjects increased their scores, ten of whom demonstrated positive changes greater than 2 inches. Two subjects regressed.

Thus the experimental factor produced substantial improvements in shoulder range of motion, forward and backward trunk flexibility. This seems to indicate that the circuit exercises are sufficiently varied to produce balanced flexibility at the specific joints or joint complexes tested.

E. Summary of Changes in Cardiovascular Condition and Motor Performance

Though improvement depends not only on an individual's level of development but also on his potential for development, one would hope to achieve, with the combination of a non-active freshman group and a good training programme, an improvement of 12-18 standard scores, while improvements of 5-6 standard scores would be only 'fair'.

Tables 33 and 34 summarize the improvements made in Cardiovascular Condition and Motor (Performance) Fitness.

The results show that there was a uniform fair improvement in each of the components of physical fitness. In each of the items of Cardiovascular Condition, about two-thirds of the subjects increased their scores while one-third did not change or have lower scores. In each of the items of Motor Performance, about three-quarters increased their scores while one quarter either did not change or gave lower scores.

TABLE 33

SUMMARY OF CHANGES IN CARDIOVASCULAR CONDITION

Variable	S. S. Increased	Stat. Imp.	Number of Changes (+)	(o)	(-)
Area Under Curve	7	*	11	1	3
Systolic Amplitude (Sitting)	1		7	0	8
Systolic Amplitude (Standing)			10	0	5
Systolic Amplitude After Exercise		*	10	0	5
Systolic Amplitude (Sit. - Stand.)	7	*	11	1	3
Diastolic Amplitude	5		10	0	5
Pulse Rate	15	*	11	0	4
Dicrotic Notch Amplitude	8	*	10	0	5
Obliquity Angle	6		9	0	6
Systolic Time			7	4	4
Diastolic Time		*	12	1	2
Rest/Work Ratio	14	*	12	0	3
600 Yard Run-Walk	3	*	12	1	2
Five Minute Step Test	5	*	10	0	5

<u>In All Tests</u>

AVer. Number (+) Changes	10.14
Aver. Standard Score Increase	7.10
Range in Standard Scores	1-15

TABLE 34

SUMMARY OF CHANGES IN MOTOR FITNESS

Variable	S. S. Increase	Stat. Imp.	Number of Changes (+)	(o)	(-)	In Each Component Aver. No. (+) Changes	Av.S.S. Increase	Range inS.S
Explosive Strength						13.00	5.33	3- 7
Illinois Agility Run	3	X	12	0	3			
50 Yard Dash	6	X	12	0	3			
Standing Broad Jump	7	X	15	0	0			
Dynamic Strength						12.50	9.00	7-11
Chins	7	X	14	0	1			
Dips	11	X	11	2	2			
Static Strength						12.00	7.75	5-15
Right Grip	5	X	11	0	4			
Left Grip	7	X	12	0	3			
Back Lift	4	X	11	0	4			
Leg Lift	15	X	14	0	1			
Strength/Weight	13	X	14	0	1			
Extent Flexibility						12.33	8.66	7-10
Shoulder Extension	10	X	13	0	2			
Trunk Extension	9	X	11	0	4			
Trunk Flexion	7	X	13	0	2			

Subjects who made positive changes in some variables did not demonstrate a like consistency in others, but there was no record of consistent improvement or regression for any individual or group of individuals except in the cardiovascular tests. In these tests, three subjects (10, 12 and 15) with initially high scores had, on the whole, lower scores on retesting and one subject (14) who had low scores initially attained still lower scores. Two subjects (4 and 5) with low initial scores had, on the whole, higher scores at retest while one subject (6) who had high scores initially attained still higher scores at retest. The same subject also attained the highest Systolic Amplitude (Sitting) - an item which seemingly is a good index of athletic potential.

For several components of Cardiovascular Condition there were two or more test items used to measure the component. In none of these components did there appear to be a relationship between the changes made by individuals on one test with the changes made by the same individuals on the other test(s). In the Stroke Volume component, although large positive changes were obtained in Rest/Work ratio, only small positive changes were obtained in Systolic Amplitude (Sitting) and only fair increases in Area Under Curve, Diastolic Amplitude, Obliquity Angle and Dicrotic Notch Amplitude. Similar inconsistencies were found in other components.

In all fourteen cardiovascular variables there were only nine with statistically significant mean improvements, the overall average score gain being 7.10 standard scores (Range: 1 to 15 standard scores).

The Motor Performance items were all statistically significant at the 0.05 level of confidence with the overall average standard score being 7.95 (Range: 3 to 15 standard scores). The average number of subjects who made positive changes was 12.05.

The two dynamic arm strength items (chins and dips) gave an average standard score improvement of 9.00 (Range: 7 to 11 standard scores), the greatest improvement of the four motor performance components tested. This was followed by the three flexibility items (Shoulder Extension, Trunk Extension and Trunk Flexion) with an average standard score improvement of 8.66 (Range: 7 to 10 standard scores). The four static strength items (Right Grip, Left Grip, Back Lift and Leg Lift) had an average standard score improvement of 7.75 (Range: 5 to 15 standard scores) while the three items utilizing explosive strength (Agility Run, 50 Yard Dash and Standing Broad Jump) showed an average standard score improvement of 5.33 (Range: 3 to 7 standard scores). This component showed the least average standard score improvement.

In each of the four main areas the average number of subjects showing positive changes, as opposed to those whose scores regressed or remained the same were approximately the same i.e. approximately three quarters of the fifteen persons participating in the study.

The fact that specific exercises will produce specific effects (task - specificity) was apparent in this study. In those fitness components in which several test items were used to measure a particular characteristic, no general pattern of change took place among items. Although very good improvements were obtained in Leg Lift, changes in Right Grip, Left Grip and Back Lift were found to be only fair. According to Karpovich (21), at the present time 'physical fitness' means merely the ability to pass physical fitness tests, so, therefore, the degree of fitness possessed by an individual depends on the character of the test and the cooperation of the subject.

Several students in the test sample seemed to present special cases. Three subjects who entered the circuit programme in 'good' condition experienced fairly consistent regression in items measuring Cardiovascular Condition. However, it does not seem reasonable to assume that the programme was inadequate to maintain the 'fitness' of the 'fit' students for these subjects could have participated in a more demanding circuit (Red 1, 2 Red 3 or Blue 1, 2 or 3). Any explanation for the changes of these subjects in the direction of 'unfitness' can only be speculative.

Several subjects who obtained low scores on the initial tests displayed consistently large positive changes in the cardiovascular items.

On the whole, it appears that the circuit programme was adequate for the 'unfit' subject.

F. Comparison Between the Circuit Training and Physical Conditioning Programme

Tables 35 and 36 give a comparison between the results obtained in the present circuit programme study and the physical conditioning programme study by Scott (22). Both programmes of ten weeks duration were required

TABLE 35

COMPARISON OF CIRCUIT TRAINING (A) AND PHYSICAL

CONDITIONING (B) EXERCISE PROGRAMS

CARDIOVASCULAR CONDITION

	S. S. Increase A	S. S. Increase B	Stat. Sign A	Stat. Sign B
Area Under Curve	7	6	X	X
Systolic Amplitude (Sitting)	1	-4		
Systolic Amplitude After Exercise	9.2%	7.0%	X	
Systolic Amplitude (Standing)	10.6%	4.4%		
Diastolic Amplitude	5	5		
Pulse Rate	15	10	X	X
Obliquity Angle	6	2		
Rest/Work Ratio	14	10	X	X
600 Yard Run-Walk	3	12	X	X
Five Minute Step Test	5	9	X	X

In All Test Items

Aver. No. (+) Changes A	Aver. No. (+) Changes B	Aver. S.S. Increase A	Aver. S.S. Increase B	Range in S.S. A	Range in S.S. B
10.20	9.60	7.00	6.25	1-15	4-12

TABLE 36

COMPARISON OF CIRCUIT TRAINING (A) AND PHYSICAL

CONDITIONING (B) EXERCISE PROGRAMS

MOTOR (PERFORMANCE) FITNESS

	S. S. Increase		Stat. Sign		In Each Component: Aver. No. (+) Changes		Aver. S.S. Increase		Range in S. S.	
	A	B	A	B	A	B	A	B	A	B
Explosive Strength					13.00	9.66	5.33	4.33	3- 7	2- 6
Illinois Agility Run	3	2	X	X						
50 Yard Dash	6	6	X	X						
Standing Broad Jump	7	5	X	X						
Dynamic Strength					12.50	8.00	9.00	6.50	7-11	2-11
Chins	7	2	X							
Dips	11	11	X	X						
Static Strength					12.00	10.25	7.75	6.00	4-15	2-10
Right Grip	5	4	X							
Left Grip	7	10	X	X						
Back Lift	4	2	X							
Leg Lift	15	8	X	X						
Extent Flexibility					12.33	10.00	8.66	4.33	7-10	1-10
Shoulder Extension	10	10	X	X						
Trunk Extension	9	1	X							
Trunk Flexion	7	2	X		In All Components					
					12.45	9.48	7.69	5.29		

physical education programmes for freshmen students at the University of British Columbia and both studies utilized the same tests which were carried out at the same times, under the same conditions and according to the same procedures.

Since the Cardiovascular Condition components used in these two studies are somewhat different - those used by Scott being from an earlier study by Cureton (23) - only the results between the specific test items will be compared.

The cardiovascular condition test items and motor performance test items, in both programmes, showed notable results in terms of both standard score increments and number of subjects making positive changes, the larger gains being in favor of the circuit programme with motor fitness component items improving to a greater extent (2.40 s.s.) than the cardiovascular component items (0.75 s.s.).

Standard score increments in items measuring 'static' endurance (Brachial Pulse Waves Measures) showed greater improvement due to the circuit training programme. This probably is explained, in part, by the extensive use of weights and repetitions in decreasing time intervals. Pulse Rate and Rest/Work Ratio tests showed the largest positive changes in both programmes.

Standard score increments in terms of measuring 'dynamic' endurance (600 Yard Run-Walk, and Five Minute Step Test) showed greater improvement due to participating in the physical conditioning programme. These results may be explained, in part, by the extensive amount of running in the conditioning programme.

In almost all motor performance items, the mean improvements made by the circuit training sample were larger than mean improvements made by the physical conditioning sample. The circuit training exercises are similar in execution to a number of the motor performance test items. It was in these items, (Chins, Trunk Extension and Trunk Flexion) that the difference between mean gains for circuit training and physical conditioning groups were largest.

Differences between the mean improvements for the components of motor performance were, in the order of size, Extent Flexibility (4 s.s.), Dynamic Strength (2 1/2 s.s.), Static Strength (2 s.s.), Explosive Strength (1 s.s.) and all were in favor of circuit training.

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CHAPTER VI

SUMMARY, CONCLUSIONS AND RECOMMENDATIONS

Summary: One of the requirements of the University of British Columbia Required Physical Education Programme is compulsory participation in a 'fitness' type activity. One of a number of these activities offered is 'circuit training'. There is a need to obtain objective data regarding the effectiveness of this activity in improving physical fitness.

The problem, in this study, was to evaluate the improvements in Cardiovascular Condition and Motor Fitness made during a circuit training class at the University. The class met twice - weekly for thirty minutes of circuit exercises for a period of ten weeks. An experimental sample of fifteen college freshmen was selected randomly from the circuit training class. The sample was given a fifteen item fitness test battery prior to and at the end of the circuit training programme. The gains in the fitness measures were evaluated in terms of the statistical significance of mean differences and in terms of standard scores established for normal young men. These results were then compared with those obtained from a Physical Conditioning Programme study which utilized the same tests, procedures and time spent in training between tests.

A comparison of the experimental group with a large group of male freshmen studied in 1962, was made in order to determine whether or not the samples were sufficiently alike in terms of height, weight and performance to regard the experimental sample as reasonably representative of male college freshmen enrolled in the Required Programme.

In none of the variables examined, was the difference between the

two groups sufficiently large to cast doubt on this proposition.

Conclusions:

On the basis of the results obtained in this study, the following conclusions seem justified:

(1) Mean differences, on the whole, were sufficiently large to indicate improvements in fitness. Twenty-two variables of the twenty-seven used showed statistically significant mean improvements. In each of the five main components, the average standard score improvement was between 5.33 and 9.00 standard scores.

(2) Three-quarters of the subjects made positive changes, on the whole, in all variables studied.

(3) The nature of the improvements made were greater, on the average, for the tests of Motor Performance than for those of Cardiovascular Condition.

(4) On the whole, subjects initially scoring high on cardiovascular items regressed and individuals who entered the programme in a 'poor' state of fitness improved considerably in both Motor Performance and Cardiovascular Condition. The majority of the subjects showed generally small but inconsistent improvements in Cardiovascular Condition.

(5) Implications from these results indicate that the programme, on the whole, may have brought about a condition of cardiovascular fatigue in the initially fit or may have been insufficient stimulus to maintain initially high cardiovascular scores. The programme was, however, adequate to produce good improvements in fitness for initially unfit subjects.

(6) Pule Rate and Rest/Work Ratio give the greatest standard score improvements for those tests of Cardiovascular Condition used in this study.

(7) In relation to Motor Performance, the circuit training programme improved dynamic (arm) strength the most, followed by extent flexibility and static strength. Explosive (leg) strength showed the least improvement of all the motor fitness components.

(8) The Circuit Training Programme appears to be superior to the Physical Conditioning Programme in improving all the aspects of Motor Performance tested and also 'static' (local) endurance in Cardiovascular condition. It is inferior, however, to the conditioning programme in improving 'dynamic' (General) endurance.

(9) Within the limitations of this study, the results obtained indicate that the Circuit Training Programme is beneficial in improving Physical Fitness although the results indicate a need for investigation of ways of increase 'dynamic' endurance.

Recommendations: It is recommended that -

(1) Further experimental studies by undertaken in order to investigate the inclusion, in the present Circuit Training Programme, of exercises which adequately foster the 'dynamic' endurance aspect of physical fitness.

(2) Studies be carried out to gauge the fitness effects of several different circuit programmes in order to design the most effective programme possible within the available time limits.

(3) Students entering the Required Physical Education Programme be classified according to their initial fitness in order to make the programme more effective. An alternate to this would be that the content and method of the programme be diversified to meet the needs of specific students or groups of students.

(4) Experimental studies be undertaken following freshmen for a much longer training period in order that more definite trends to change can be established.

(5) Studies be made comparing the effectiveness of the circuit training programme with other programmes promoting physical fitness.

(6) Further experimental studies be carried out to accurately determine the physiological significance of the Cameron Heartometer measures in order to obtain a significant and meaningful classification of cardiovascular condition components.

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KEY TO APPENDICES A TO F

A Statistical Treatment

B Procedure Timetable

C Individual Score Sheet

D Health-Habit Questionnaire

E Exercise Procedure

F Cardiovascular Condition Table of Rotated Factors

APPENDIX A

STATISTICAL TREATMENT

Study Design

Single Group, Test-Retest Experiment (N = 15)

X Initial Test - Experimental Factor (Circuit Training) X Final Test = Difference

Procedure

1. Random selection of sample from the Circuit Training Class.
2. Administration of fitness test battery to sample to obtain initial scores.
3. Participation of sample in regular Circuit Training Class for eight weeks.
4. Administration of fitness test battery to sample to obtain final scores.

General Statistical Outline

The following calculations were made:

1. Comparison of the test sample with the 1962 University of British Columbia AAHPER Fitness Test Sample with respect to height, weight and performance in chinning, standing broad jump, 50 yard dash and 600 yard run-walk.
2. The significance of difference in performance of the experimental group on the initial and final tests.

Procedure and Formulae

1. Determination of whether sample selected could be considered representative of male freshmen students enrolled in the Required

Physical Education Programme at the University of British Columbia.

Estimation of sampling error in order to test probability that differences between means could have arisen solely from random errors of sampling. Standard Duration of population (U.B.C. AAHPER Fitness Test 1962) sample was known.

(Walker and Lev, 2, pp. 144-145)

$$Z = \frac{\sqrt{N_E}\,(M_P - M_E)}{SD_P}$$

M_P - Population (U.B.C. AAHPER) mean

M_E - Experimental sample mean

SD_P - Standard Deviation of population

N_E - Number in experimental sample

Z - Z score obtained for variable

a - Area outside two ordinates of Z (probability that difference between means could have occurred due to chance)

Acceptable at minimum of 0.05 for accepting null hypothesis.

2. Significance of differences in performance of group on initial and final tests.

Difference Method (Garrett, 1, p. 227)

M_D - Mean of difference between initial and final tests

SD_D - Standard Deviation of differences

SE_D - Standard error of mean of differences t - $\frac{M_D - 0}{SE_{MD}}$ (Acceptable at the 5 percent level of confidence)

df - Degrees of freedom

N-1 - Number in sample minus one

Fitness Test Battery

A. Cardiovascular Condition Items

Component I - Stroke Volume (Blood Ejection Velocity from the Heart)

(1) Heartometer - Area Under Curve

(2) Heartometer - Systolic Amplitude Sitting

(3) Heartometer - Systolic Amplitude Standing

(4) Heartometer - Systolic Amplitude After Exercise

(5) Heartometer - Diastolic Amplitude

(6) Heartometer - Dicrotic Notch Amplitude

(7) Heartometer - Obliquity Angle

(8) Heartometer - Diastolic Time

(9) Heartometer - Systolic Time

(10) Heartometer - Rest/Work Ratio

Component VI - Endurance In Short Hard Work.

600 Yard Run-Walk

Component VII - Vagus Tone

(1) Heartometer - Pulse Rate Sitting

(2) Five Minute Step Test

Component VIII - Splanchnic (Circulatory) Ptosis

(1) Heartometer - Area Under Curve

(2) Heartometer - Systolic Amplitude Sitting to Standing

B. Motor Performance Fitness Items

Component I - Agility

Illinois Agility Run

Component II - Speed

50 Yard Dash

Component III - Power

Standing Broad Jump

Component IV - Dynamic Strength and Muscular Endurance

(1) Chins

(2) Dips

Component V - Static Strength

(1) Dynamometer - Right Hand Grip

(2) Dynamometer - Left Hand Grip

(3) Dynamometer - Back Lift

(4) Dynamometer - Leg Lift

(5) Total Strength/Pound of Body Weight

Component VI - Extent Flexibility

(1) Cureton Shoulder Extension

(2) Cureton Trunk Extension

(3) Cureton Trunk Flexion

APPENDIX B

PROCEDURE TIMETABLE

(1) Class Day 1 - Selection of Experimental Sample

(2) Class Day 2 - Administration of Group I test items to entire group.

Group I items:

Chins

Standing Broad Jump

50 Yard Dash

600 Yard Run-Walk

(3) Week of Class 2 - Administration of Group II, III and IV test items during three individual appointments.

Appointment 1 - Group II items:

Heartometer

Dips

Cureton Flexibility

(a) Shoulder Extension

(b) Trunk Extension

(c) Trunk Flexion

Illinois Agility Run

Appointment 2 - Group III items:

Dynamometrical Strength

(a) Right Hand Grip

(b) Left Hand Grip

(c) Leg Lift

(d) Back Lift

Appointment 3 - Group IV item:

Five Minute Step Test

(4) Class Days 4 to 20 - Participation in Circuit Training Class

(5) Class Day 21 - Administration of Group I items.

(6) Week of Class 22 - Administration of Groups II, III and IV items in the same manner as in initial test.

APPENDIX C

INDIVIDUAL SCORE SHEET

Name:

Address:

Telephone:

	Initial	Final
Chins	______	______
Standing Broad Jump (ins.)	______	______
50 Yard Dash (secs.)	______	______
600 Yard Run-Walk (secs.)	______	______
Heartometer	______	______
Flexibility (ins.)	______	______
Shoulder Extension	______	______
Trunk Extension	______	______
Trunk Flexion	______	______
Dips	______	______
Illinois Agility Run (secs.)	______	______
Dynamometric Strength (lbs.)	______	______
Right Grip	______	______
Left Grip	______	______
Back Lift	______	______
Leg Lift	______	______
Five Minute Step Test (total pulse count)	______	______

APPENDIX D

PHYSICAL EDUCATION REQUIRED PROGRAMME

Health - Habit Questionnaire

Name: ____________________

Address: ____________________ Phone: __________

P.E. Course: __________ Main Field of Study: __________

Age: __________ Height: __________ Weight: __________

Instructions:

Please answer as carefully and as accurately as you can each of the following questions concerning your health habits. You are asked for this information in order that we may more accurately analyze the results of your physical fitness tests. Your answers will be kept confidential.

Section A is to be completed and returned at the next class meeting. Section B will be completed at the time of the final testing.

Section A:

1. Have you experienced any illness since the term began? (include severe colds). __________ If so list:

   (a) __________ How Long __________

   (b) __________ __________

   (c) __________ __________

2. Do you smoke? __________ If so, how much?

   Cigarettes __________

   Cigars __________

   Pipe __________

3. How many hours of sleep per night on the average? ____________________

   What is your usual time of going to bed? ____________________________

4. Do you eat at home, residence hall, fraternity, cook for self, cafeteria or restaurant? Indicate which ______________________________

5. If you have a part time job during the term, indicate how many hours per week. __________________ What are your hours of work? ____________

6. Before this term began were you doing any regular vigorous exercise or hard manual work? ______________________ If so, how many hours per day? (approximately) __________________

7. Are you engaging in any regular physical exercise or activity or hard manual work (other than this class) during this term? ________________

   If so, how many hours per day? __________

8. Is there anything in your present mode of living which in your opinion might adversely or favourably influence your physical fitness?

   If so, discuss:

9. When you started the physical conditioning class this term did you consider yourself to be in good__________, fair__________, poor________, physical condition as a result of your summer activities.

Section B:

1. Have you had a severe cold or other illness recently? _________________

   If so, describe:

2. Has there been any recent change in your mode of living (smoking, sleeping, eating, working, exercises, etc.) which might adversely or beneficiently affect your state of physical fitness? _________________

   If so, describe:

APPENDIX E

EXERCISE PROCEDURE

Station 1 - Squat Thrust

Position: Standing erect with arm at sides and feet together.

Movement: Lower body to a squat-rest position, leaning forward, and placing hands on floor in front of feet. Thrust legs backward to front leaning - rest (push-ups) position. Return to squat rest position and then to standing position with head up.

Instruction: Legs should be fully extended from squat-rest position and body fully erect in standing position.

Body Regions Exercised: A general activity.

Stabilization: Shoulder girdle in squat-rest position.

Station 2 - Two Arm Reverse Curl

Position: Thigh-rest position, pronated grip and feet shoulder width apart.

Movement: Raise bar bell to shoulders by bending elbows. Lower bar bell until arms are fully extended.

Instructions: Elbows should be kept close to sides throughout movement. Body is kept erect with no movement and no wrist bending.

Body Regions Exercised: Front of upper arm, back of forearm and wrists.

Station 3 - Two Arm (Posterior Military) Press

Position: Shoulder-rest position with bar resting on back of neck and shoulders, pronated grip and body erect with eyes straight ahead and chest out.

Movement: Press bar overhead from this position until arms lock. Then lower bar to shoulder-neck position.

Instructions: Breathe in before or during press. Keep bar directly over shoulders throughout movement. Head should be bent slightly forward when pressing and returning bar.

Body Regions Exercised: Shoulders, upper chest, back and back of upper arms.

Stabilization: Legs, hips and trunk.

Station 4 - Straddle Bench Jump

Position: Standing in erect position straddling bench. Dumbbells at sides of body with palms facing toward body,

Movement: Jump from straddle position on floor to top of bench. Return to straddle position on floor.

Instructions: Keep head up, back straight and arms extended at side.

Body Regions Exercised: Legs.

Stabilization: Shoulder girdle, trunk and pelvic regions.

Station 5 - Standing Lateral Raise

Position: Standing erect with feet shoulder width apart, arms extended at the sides and palms facing the body holding dumbbells.

Movement: Lift the dumbbells directly sidewards to the overhead position. Lower to starting position.

Instructions: Be sure to maintain proper body alignment in all segments while lifting and lowering the weights.

Body Regions Exercised: Outer portion of shoulders.

Stabilization: Pelvic and Thoracic regions.

Station 6 - Lying Lateral Raise

Position: Lying supine on bench with arms extended from shoulders in stretch or "T" position. Dumbbells grasped with palms facing upward.

Movement: Raise arms directly upward to perpendicular position above shoulders. Lower slowly to starting position.

Instructions: Head should be kept steady in a position with face directed upward. Buttocks should remain on bench throughout movement. Legs should be relaxed with feet, shoulder width apart, not pushed against floor.

Body Regions Exercised: Anterior shoulder and chest.

Stabilization: Weight of body will stabilize trunk, shoulder girdle and pelvic girdle. Abdominal muscles stabilize chest.

Station 7 - Sit Ups

Position: Supine position with legs straight and feet hooked under railing. Hands clasped behind neck.

Movement: Curl head forward until chin on chest and then raise [illegible] upper back off floor, bending forward bringing elbows to knees. Return to starting position.

Instructions: Be sure movement begins by bending neck forward and then progressing down back. Lower or curl back to original position by touching lower back, then upper back and head last. May vary exercise by bringing right elbow to left knee on one sit up and then left elbow to right knee on next. (Exercise can be varied by performing it with knees bent thus placing greater emphasis on the abdominal muscles by eliminating hip flexors).

Body Regions Exercised: Abdomen

Stabilization: Pelvic region, legs, and thoracic region.

Station 8 - Bench Step-Ups

Position: Standing in erect position in front of bench 18 to 20 inches high.

Movement: Place one foot on bench, step up until both feet are fully on bench, with legs straightened and body erect, and immediately step down again one foot at a time.

Instructions: Subject counts off pace - "Up - 1 - Down - 2, Up - 1 - Down - 2". "Up" comes every 2 seconds.

Body regions Exercised: A general activity.

Stabilization: Thoracic girdle.

Station 9 - Jump Chins

Position: From erect position under bar, jump up and grip bar with pronated grip, shoulder width apart.

Movement: From hanging position, raise body up by arms until chin is over bar. Return to hanging position and then to floor.

Instructions: Subject is not permitted to kick, jerk, or use a "kip" motion. Any such maneuver or failure to go down until the arms are straight or up to prescribed position counts half a movement.

Body Regions Exercised: Arm and shoulder flexors and chest.

Stabilization: Pelvic girdle, thoracic girdle and legs.

Station 10 - Bench Press

Position: Lying supine on bench with knees bent and feet flat on floor. Hold barbell in chest-rest position, pronated grip.

Movement: Press barbell directly upward until arms lock. Lower to chest. Repeat.

Instructions: Buttocks should remain on bench throughout movement. Legs should be shoulder width apart and relaxed. Feet should not push against the floor.

Body Regions Exercised: Front of shoulders, chest and back of upper arms.

Stabilization: Weight of body will stabilize trunk, shoulder girdle and pelvic girdle. Abdominal muscles stabilize chest.

Station 11 - Trunk Extension (Reverse Sit Ups)

Position: Lying across bench in prone position with heels hooked under bar and hands clasped behind neck.

Movement: Raise upper half of body as high as possible and return to original position.

Instructions: It is a sharp movement in the thoracic region as opposed to a rolling movement.

Body Region Exercised: Lower Back.

Stabilization: Pelvic girdle, legs and shoulder girdle.

Station 12 - Bent Over Rowing

Position: Dead lift position. Toes near bar, feet comfortably spread, knees straight, back straight, hips flexed and hands gripping bar at little more than shoulder width, pronated grip.

Movement: Lift bar to chest by bending elbows and pulling arms upward, then lower to starting position.

Instructions: No movement except at elbows and shoulder joints. Movement done in same manner as rowing a boat. Legs must be relatively straight throughout movement, although knees can be slightly flexed.

Body Regions Exercised: Back, back of shoulders, front of upper arms.

Stabilization: Legs, pelvic and shoulder girdle and back.

Station 13 - Stair Running

Position: Standing erect facing the stairs.

Movement: Climb the stairs at a running pace and return to the bottom.

Instructions: Breathe deeply during running. Stairs may be taken one or two at a time or a combination of both for variety.

Body Regions Exercised: A general activity.

Stabilization: None

APPENDIX F

CARDIOVASCULAR CONDITION FINAL ROTATED FACTOR TABLE[*]

Heartogram: Brachial Pulse Wave

Basic Tests and Measurements	Units	Blood Ejec. Velocity Pulse Rate	End. in Short Hard Run (All-out Trdml. Run	Vagus Tone (Slow Pulse Rate)	Splanchnic Ptosis (Pulse Wave Decrement)
<u>Sitting</u>					
Pulse Rate	Beats/Min.	-.46	-0.04	-.60	-.06
Area	Mm^2	.50	.01	.12	.52
Systolic Amplitude	Mm	.68	.00	-.11	.33
Diastolic Amplitude	Mm	.63	-.00	-.04	.46
Dicrotic Notch Amplitude	Mm	.31	-.00	.16	.36
<u>Standing</u>					
Systolic Amplitude	Mm	.66	.05	-.04	-.24
<u>After 1' Run in Place</u>					
Systolic Amplitude	Mm	.58	.09	.02	-.10
<u>Change</u>					
Systolic Amplitude (Sit.-Stand.)	Mm	.02	-.07	-.10	.76
<u>Five Min. Step Test</u>					
Total Pulse Count	Beats	.03	-.01	-.57	.11
<u>All-Out Treadmill Run</u>					
Run Time: 7Mi/Hr/8.6% Grade	Minutes	.03	.60	-.04	.03

[*]Abbreviated from Cureton and Sterling (3).

KEY TO APPENDICES G TO J

G Cardiovascular Condition Items - Raw Scores for Initial Test

H Cardiovascular Condition Items - Raw Scores for Final Test

1. Area Under Curve
2. Systolic Amplitude Sitting
3. Systolic Amplitude Standing
4. Systolic Amplitude After Exercise
5. Diastolic Amplitude
6. Dicrotic Notch Amplitude
7. Obliquity Angle
8. Diastolic Time
9. Systolic Time
10. Rest/Work Ratio
11. Systolic Amplitude Sitting to Standing
12. Pulse Rate Sitting
13. 600 Yard Run-Walk
14. Five Minute Step Test

I Motor Fitness Items - Raw Scores for Initial Test

J Motor Fitness Items - Raw Scores for Final Test

1. Illinois Agility Run
2. 50 Yard Dash
3. Standing Broad Jump
4. Chins
5. Dips
6. Right Hand Grip

7. Left Hand Grip
8. Back Lift
9. Leg Lift
10. Total Strength/Pound of Body Weight
11. Cureton Shoulder Extension
12. Cureton Trunk Extension
13. Cureton Trunk Flexion

APPENDIX G

CARDIOVASCULAR CONDITION ITEMS RAW SCORES FOR INITIAL TEST

Subject	Item 1 sq.cms.	Item 2 cms.	Item 3 cms.	Item 4 cms.	Item 5 cms.	Item 6 cms.	Item 7 degs.	Item 8 cms.	Item 9 cms.	Item 10	Item 11 cms.	Item 12 no/min	Item 13 secs.	Item 14 no.
1	0.60	1.20	0.60	1.63	0.37	0.36	22.8	0.28	0.22	1.27	0.60	108	98	192
2	0.33	1.01	0.68	0.94	0.37	0.36	22.7	0.44	0.24	1.83	0.33	76	99	201
3	0.35	0.76	0.41	0.64	0.28	0.32	24.3	0.30	0.25	1.20	0.35	92	122	183
4	0.40	0.89	0.49	0.70	0.48	0.49	23.7	0.37	0.26	1.42	0.40	90	113	188
5	0.03	0.76	0.73	1.11	0.56	0.56	24.7	0.50	0.24	2.08	0.03	84	120	171
6	0.54	1.26	0.72	1.70	0.52	0.46	21.4	0.53	0.24	2.21	0.54	80	104	181
7	0.28	0.79	0.51	1.12	0.49	0.50	24.6	0.40	0.24	1.67	0.28	90	105	197
8	0.23	1.19	0.96	1.58	0.49	0.52	21.9	0.43	0.26	1.65	0.23	82	98	169
9	0.54	1.14	0.60	1.33	0.49	0.49	21.8	0.51	0.23	2.22	0.54	72	116	171
10	0.64	1.49	0.85	1.45	0.72	0.73	20.8	0.57	0.21	2.71	0.64	68	107	204
11	0.02	0.47	0.45	1.36	0.26	0.27	27.2	0.34	0.24	1.42	0.02	92	102	183
12	0.33	1.27	0.94	1.62	0.52	0.52	20.7	0.40	0.22	1.82	0.33	79	98	182
13	0.15	0.74	0.59	0.55	0.45	0.50	24.8	0.42	0.27	1.55	0.15	84	122	185
14	0.14	0.64	0.50	0.94	0.33	0.34	25.5	0.41	0.26	1.58	0.14	80	119	191
15	0.22	1.06	0.84	1.05	0.59	0.61	21.7	0.57	0.24	2.37	0.22	60	94	165
Mean	0.25	0.98	0.66	1.18	0.46	0.44	23.24	0.43	0.24	1.80	0.32	82.50	107.80	184.20

APPENDIX H

CARDIOVASCULAR CONDITION ITEMS RAW SCORES FOR FINAL TEST

Subject	Item 1 sq.cms.	Item 2 cms.	Item 3 cms.	Item 4 cms.	Item 5 cms.	Item 6 cms.	Item 7 degs.	Item 8 cms.	Item 9 cms.	Item 10	Item 11 cms.	Item 12 no/min	Item 13 secs.	Item 14 no.
1	0.28	0.97	1.03	1.65	0.46	0.46	22.9	0.56	0.23	2.43	-0.06	68	97	193
2	0.33	1.17	0.84	1.32	0.51	0.48	20.5	0.52	0.24	2.17	0.33	66	98	191
3	0.26	0.61	0.47	0.90	0.43	0.46	25.8	0.73	0.21	3.48	0.14	64	120	167
4	0.34	1.02	0.75	1.02	0.53	0.55	23.5	0.63	0.24	2.63	0.27	64	110	176
5	0.34	1.11	0.80	1.38	0.63	0.65	22.1	0.51	0.25	2.04	0.31	64	113	165
6	0.39	1.25	0.93	1.44	0.63	0.64	20.4	0.70	0.22	2.41	0.32	55	101	168
7	0.20	0.85	0.60	1.43	0.37	0.40	22.4	0.46	0.25	1.84	0.25	74	105	196
8	0.32	1.15	0.90	1.63	0.54	0.56	21.6	0.53	0.23	2.30	0.23	76	97	165
9	0.40	1.25	0.82	1.68	0.75	0.83	21.3	0.43	0.25	1.72	0.43	76	114	173
10	0.43	1.06	0.73	1.41	0.62	0.63	22.0	0.76	0.21	3.62	0.33	58	104	200
11	0.25	1.02	0.43	1.34	0.43	0.42	21.7	0.44	0.23	1.91	0.59	84	108	173
12	0.19	0.94	0.70	1.37	0.32	0.30	22.1	0.35	0.22	1.59	0.24	88	100	184
13	0.29	1.08	0.68	0.92	0.53	0.55	23.8	0.48	0.23	2.09	0.40	82	119	180
14	0.14	0.52	0.54	1.04	0.27	0.29	27.9	0.41	0.24	1.71	-0.02	83	118	196
15	0.31	0.96	0.76	0.81	0.55	0.56	22.8	0.60	0.24	2.50	0.20	63	90	170
Mean	0.30	1.00	0.73	1.29	0.50	0.52	22.72	0.53	0.23	2.29	0.26	71.00	106.30	179.80

APPENDIX I

MOTOR PERFORMANCE ITEMS RAW SCORES FOR INITIAL TEST

Subject	Item 1 secs.	Item 2 secs.	Item 3 ins.	Item 4 no.	Item 5 no.	Item 6 lbs.	Item 7 lbs.	Item 8 lbs.	Item 9 lbs.	Item 10	Item 11 ins.	Item 12 ins.	Item 13 ins.
1	17.5	6.6	93	6	14	128	120	340	480	6.78	8.0	14.9	13.6
2	17.2	6.6	94	4	5	128	138	410	736	7.34	10.5	17.0	8.3
3	21.0	7.6	87	9.5	10	118	105	263	365	5.87	14.2	20.3	8.6
4	17.9	6.9	90.5	6	6	137	125	428	500	7.26	11.4	17.3	13.2
5	18.3	7.2	94	8.5	24	128	112	375	585	7.83	3.9	8.9	19.3
6	17.6	6.5	97	8.5	17	119	109	361	542	7.96	4.6	12.1	11.1
7	18.4	7.0	96	4	4	142	122	425	530	7.05	15.2	19.3	9.0
8	18.8	7.4	86	7.5	17	128	128	354	512	7.33	12.3	19.5	10.5
9	19.0	7.3	77	8.5	20	131	105	375	358	7.69	8.9	17.2	17.2
10	18.4	6.8	85	6.5	10	131	118	372	438	6.23	12.0	16.6	10.8
11	18.8	6.7	97	3	6	108	87	310	391	5.78	8.6	12.8	12.5
12	17.7	6.7	92	3	8	95	118	385	350	5.58	5.0	17.3	11.5
13	19.1	7.3	76	6	14	113	105	337	452	7.24	7.3	15.0	12.5
14	20.2	7.0	80.5	0	4	85	64	290	390	4.53	5.0	7.9	18.5
15	17.4	6.2	94.5	11	17	128	98	365	485	6.86	9.5	20.5	9.9
Mean	18.48	6.92	89.3	6.13	11.73	121.27	110.26	359.33	474.27	6.75	9.09	15.77	12.43

APPENDIX J

MOTOR PERFORMANCE ITEMS RAW SCORES FOR FINAL TEST

Subject	Item 1 secs.	Item 2 secs.	Item 3 ins.	Item 4 no.	Item 5 no.	Item 6 lbs.	Item 7 lbs.	Item 8 lbs.	Item 9 lbs.	Item 10	Item 11 ins.	Item 12 ins.	Item 13 ins.
1	17.3	6.5	95	8	19	133	119	368	611	7.82	8.4	15.7	10.5
2	17.0	6.7	97	5.5	5	140	142	440	670	7.23	17.5	24.1	1.7
3	19.8	7.1	93.5	11	9	117	100	281	471	6.68	13.6	22.6	11.6
4	17.4	6.7	92	5.5	10	132	126	433	738	8.71	11.0	17.6	11.6
5	18.6	6.6	96	10.5	28	131	117	425	635	8.54	4.2	15.4	16.1
6	16.7	6.3	98.5	11.5	20	128	100	400	585	8.54	7.6	15.6	12.6
7	18.3	6.6	97	4.5	5	150	135	480	650	8.18	15.7	22.6	6.3
8	18.1	7.2	88	9	14	132	138	370	605	8.14	20.4	22.5	7.6
9	18.5	7.0	78	10	23	138	118	360	395	8.02	10.1	25.2	14.7
10	18.5	6.3	88	8.5	15	130	122	375	440	6.28	14.1	17.3	8.3
11	18.4	7.0	100	4	17	112	101	330	445	6.37	10.6	12.3	10.1
12	18.1	6.8	94	4.5	17	131	148	380	530	6.99	9.3	15.4	10.8
13	18.7	7.0	83	7	17	120	110	360	505	7.88	8.1	14.0	11.6
14	19.8	6.5	81	1	4	88	73	287	471	5.64	8.2	19.0	16.4
15	16.5	6.1	96	12	20	124	108	330	615	7.49	12.9	20.1	7.1
Mean	18.11	6.69	91.8	7.50	14.86	127.07	117.13	374.60	557.73	7.50	11.45	18.62	10.46

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