THE EFFECTS OF AN ENDURANCE EXERCISE PROGRAM ON CARDIOVASCULAR VARIABLES OF A GROUP OF MIDDLE-AGED MEN

by

GORDON ALBERT ALEXANDER OLAFSON

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We accept this thesis as conforming to the required standard:

THE UNIVERSITY OF BRITISH COLUMBIA

April, 1966
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Department of School of Physical Education and Recreation

The University of British Columbia
Vancouver 8, Canada

Date April 19, 1966.
ABSTRACT

The purpose of this study was to evaluate the effects of an endurance exercise program on a group of middle-aged men. Ten subjects were tested before and after seventeen weeks of endurance training at The University of British Columbia using five tests, three of which were tests of cardiovascular condition.

The tests used are as follows:

1. Schneider Test

Variables are: lying pulse rate, standing pulse rate, post-exercise pulse rate, time for pulse rate to return to standing value, difference between pulse rate lying to standing, and standing to post-exercise difference, lying systolic blood pressure, standing systolic blood pressure, the difference between lying and standing systolic blood pressure and Schneider index score.

2. Progressive Pulse Ratio

Variables are: recovery pulse counts for rates of 12, 18, 24, 30 and 36 steps per minute, average ratio and average angle.

3. Pulse Pressure Wave. (Brachial Sphygmograph)

Variables are:

A. Sitting

area under the curve, systolic amplitude, dicrotic notch amplitude, fatigue ratio, diastolic amplitude, rest-to-work ratio, obliquity angle, systolic time, diastolic time, pulse rate, systolic blood pressure, diastolic blood pressure and pulse pressure.
B. **Standing**

area under the curve, pulse rate, systolic amplitude, difference between sitting and standing systolic amplitude.

C. **Post-Exercise**

systolic amplitude

4. **Body Fat Measurements**

Variables are: cheek fold, abdominal fold, hip fold, front thigh fold, gluteal fold, rear thigh fold, sum of all and average.

5. **Body Weight**

Significant changes at the .05 level of confidence occurred in ten variables of forty-four used in this study. A significant reduction in body fat at the .05 level of confidence occurred in the abdominal fold, front thigh fold, gluteal fold, sum of all and average of all, though a reduction in body weight was not significant at the .05 level of confidence. Sitting pulse rate, sitting systolic blood pressure, standing area under the curve and standing pulse rate of the Pulse Pressure Wave were significant at the .05 level of confidence. One variable of the Schneider Test - time for the pulse to return to standing value - was significant at the .05 level of confidence. No significant changes occurred in the Progressive Pulse Ratio Test variables.

Only three correlation co-efficients were of sufficient size to be considered significantly different from zero. These were the co-efficients of correlation between attendance and average pulse ratio, front thigh fat fold and rear thigh fat fold.
Although only five of thirty-five cardiovascular variables showed statistically significant improvements, the members of the group stated that their tolerance to the stress of the endurance exercise program had improved.
ACKNOWLEDGEMENT

The writer wishes to express his sincere appreciation to his advisor, Dr. S.R. Brown, for his patient guidance, counsel, and invaluable assistance in the research laboratory. In addition, I would like to express my thanks to Dr. E.W. Banister who also assisted in the research laboratory. To Dr. P. Mullins, Dr. N. Watt, Dr. A. Cox, and Mr. R.F. Osborne, I would like to extend my appreciation for the suggestions and guidance they gave as my Committee. Finally, I would like to thank Dr. D. McKie for his advice concerning the statistical treatment of this study.
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CHAPTER I

THE PROBLEM AND ITS BACKGROUND

Research on the work capacity of middle-aged men has shown that variables such as age, environment and work conditions do affect the level of fitness (1). With the average life-span steadily increasing, the problem confronting physical educators is how to develop the desire for physical activity since as the average person becomes older, his desire to remain physically active lessens resulting in a decreased physical work capacity (2). Though research indicates there is a steady decline in the physical work capacity of the sedentary middle-aged man, there is evidence that the capacity to perform a task without undue fatigue can be elevated as a result of participation in a physical exercise program (3,4).

The question remains as to the kind of exercise programs and the amount of exercise which are best suited to the 'average' middle-aged man. Medical authorities indicate that an exercise program should be realistically adjusted to suit the physical condition of the subject. There is also a problem of selecting a suitable test which will best serve the purpose of evaluating the cardiovascular condition of the subject and will thereby permit the investigator to select an appropriate program of exercise which will result in maximum cardiovascular improvement in a minimum amount of time.

Investigators are pursuing the question of whether or not exercise is a prophylaxis against heart disease. The question whether or not physical exercise is beneficial in reducing the increasing
incidence of heart disease and whether or not exercise can be used in the rehabilitation of cardiac patients still remains unanswered.

Physical education has a responsibility to investigate the effects of exercise upon the fitness of middle-aged men and to provide advice on the selection and use of suitable instruments for measuring cardiovascular fitness (5). The Schneider Test, the Progressive Pulse Ratio Test and the Pulse Pressure Wave Test have served as useful indicators of cardiovascular condition in athletes and non-athletes. These parameters measure certain aspects of circulatory function during rest, exercise and following exercise and reflect the ability of the cardiovascular system to adjust to postural changes and to progressively increasing workloads.

This study was undertaken to investigate the effects of an endurance exercise program on the cardiovascular fitness of university staff and faculty.

THE PROBLEM

Statement of Problem

The problem of this study was to determine the effects of participation in an endurance exercise program upon the cardiovascular fitness of a group of middle-aged men as measured by pulse rate, blood pressure and pulse pressure wave tests.

Hypothesis

That the subjects taking part in the endurance exercise program
will show significant improvement in cardiovascular fitness.

Limitations
1. Variables outside the training and experimental environments could not be controlled although the subjects were asked to deviate as little as possible from their normal daily regime.
2. The effects of psychological apprehension of the subject on test results were non-controlled.
3. The ten subjects used in this study were Faculty and Staff at The University of British Columbia.

Assumptions
1. Cardiovascular condition is an important factor in the measurement of physical fitness and certain aspects of it can be measured by such externally monitored phenomena as pulse rate, blood pressure, and pulse waves.
2. The pulse pressure wave as recorded by the Cameron Heartometer reflects certain hemodynamic phenomena which are capable of being modified by an endurance exercise program.
3. The Progressive Pulse Ratio Test measures cardiovascular response to work of a graded intensity through submaximal to maximal.
4. The Schneider Test indirectly reflects the action of the autonomic nervous mechanism in response of postural changes and to exercise of very brief duration.
5. Diurnal variation in circulatory measurements was controlled by testing each subject at the same time of the day for all three tests.
6. Changes in measurements were due primarily to changes in cardiovascular fitness and were not due to learning effects. This assumption appeared to be tenable as the tests were separated by considerable periods of time and were only performed twice.

7. The measurements made were all reliable estimates of the subjects' true scores.

Definitions

1. 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" (6). This is also known as cardiovascular fitness, cardiorespiratory fitness or circulatory endurance.

2. Sitting Pulse Pressure Wave.
   A. Area under the curve - reflects somewhat the blood pumped per stroke of the heart and also the arterial tonicity (7).
   B. Systolic Amplitude - indicates the magnitude of the heart contraction or systole (8).
   C. Dicrotic Notch Amplitude - indicates the diastolic blood pressure which acts as a back pressure to close the semilunar valves. It reflects the cardiovascular tone of associated arteries (9).
   D. Fatigue Ratio - reflects the relationship between the amplitude of systole to the amplitude of the dicrotic notch. A low
fatigue ratio is associated with the lowering of the diastolic blood pressure, which may in some instances be associated with apprehension or fear. A high fatigue ratio is normally associated with good cardiovascular condition (10).

E. Angle of Obliquity - the larger angle is associated with a slow, sluggish heart action. However, a slow rate in older subjects may also result in a larger angle due to a slowing of the heart rate with age. A smaller angle denotes a fast and more efficient systole (11).

F. Diastolic Pulse Wave Amplitude - indicates the phase of the cardiac cycle associated with the decline of the diastolic pressure (12).

G. Diastolic Surge - is probably caused by reflected pressure wave from the active contraction of the aorta after the lowest point of the Dicrotic Notch. It is developed by active athletic subjects (13).

H. Time of Diastole - is a measure of the time of the diastole after the closing of the semilunar valves (14).

I. Time of Systole - shorter systole is generally associated with young subjects at rest, as contracted to a slow sluggish systole associated with the unfit (15).

J. Rest to Work Ratio - is a comparison of systolic time to diastolic time; the resultant ratio if it is 4 to 1 is indicative of a strong efficient cardiovascular system whereas a 1.21 to 1 ratio is indicative of an untrained cardiovascular system (16).
   A. Area under the Curve - reflects the cardiovascular adjustment to postural change. The smaller the difference between the sitting and standing area under the curve, the better the adjustment (17).
   B. Systolic Amplitude - The smaller the difference between the sitting and standing systolic amplitudes, the better the adjustment (18).

4. Post-Exercise Pressure Pulse Wave.
   Systolic Amplitude - reflects the circulatory adjustment to a one minute run in place at a frequency of one hundred and eighty steps per minute (19).

5. Pulse Rate - is the regular rate of heart beat taken in beats per minute from the pulse wave tracing or by a stethoscope (20). There is a tendency for the pulse rate to be lower in subjects who are in good physical condition (21).

6. Recovery Pulse Rate - The time for the heart rate to return to normal after exercise depends on the work load of the exercise period and on the physical condition of the subject. In men in good physical condition recovery occurs more rapidly than in fatigued or poorly trained subjects.

7. Pulse Ratio - is the ratio of the quiet sitting pulse rate before exercise divided into the total pulse count for two minutes taken from ten seconds after the exercise. The smaller the ratio at each level of stepping, the more efficient is the adjustment to the work task (23).
Justification of the Problem

With the renewed interest of Canadians in physical fitness, as exemplified by the establishment of the Canada Fitness and Amateur Sport Directorate, Health Spas, and Y.M.C.A. Health Clubs, the middle-aged man is becoming aware of the need for and benefits of remaining physically fit. In order to be successful, the university professor must develop his mental capabilities to the fullest extent. If he wishes to advance himself within the academic community, he must concern himself with research, writing and publishing papers, but he often does little to develop or maintain a sound body. Because of his inactive life, his body may rapidly deteriorate resulting in poor circulation, nervous tension and over-weight. The professor thus becomes an office worker who is subject to a loss of physical fitness mainly due to a lack of physical exercise (24).

Research indicates that daily training will under normal circumstances improve the cardiovascular condition of the middle-aged man. The type of program offered will determine the degree of improvement (25). Neuromuscular and psychological factors may, however, also determine and limit the working capacity of the individual (26). When the work is increased to exhaustion one gets a measure of the will power of the subject and of the maximum ability of the muscles to work under anaerobic conditions. It is a well-known fact that the trained athlete displays a slower resting heart rate and has greater ability to sustain a given work task longer than the non-athlete (27). Studies dealing with the effects of aging have indicated that a decrease in work
capacity accompanies the onset and advancement of middle-age.

Coronary heart disease and other related cardiac disorders have resulted in an increasing mortality rate in recent years. Investigations indicate that there is a probable relationship between the incidence of coronary heart disease and of physical inactivity (28, 29, 30, 31). It seems, therefore, that in addition to improvement in general well-being and function, regular exercise may also offer important prophylactic benefits. Some indirect evidence of the possible beneficial effects of exercise on the myocardium and blood vessels may be provided by experimental proof of the changes in cardiovascular condition which can be produced by exercise programs. It is also important to know the most efficient and least time consuming methods of producing desirable effects on the cardiovascular system since the great concern of busy professional men is to obtain maximum benefits in the small amount of time they can afford for participation in exercise programs. The achievement of these ends would appear to justify continued research.


8. Ibid., pp. 236-240.


10. Ibid., pp. 243-244.

11. Ibid., p. 244.

12. Ibid., p. 247.

13. Ibid., pp. 247-249.


15. Loc. cit.

16. Loc. cit.

17. Ibid., p. 235.


22. Ibid., p. 104.


Research on the middle-aged man and his response to physical exercise is somewhat obscured by the difficulty of giving meaning to the term 'middle-age'. Although most of the literature arbitrarily assumes middle-age to begin at thirty, Guild (1) defines "middle-age as beginning approximately three years after college".

There is general agreement that man's ability to participate in hard endurance exercise is limited by his cardiovascular, respiratory and neuromuscular performance (2). Although the latter must be considered an integral part of the first two criteria, the physiological factors of cardiovascular and respiratory performance have received greater emphasis. Associated with this research is the problem of whether or not the decline in cardiovascular fitness can be attributed to chronological or physiological age. Knutti (3) considers the decrement to be related to changes in living habits and experiences encountered each day. Brouha and Radford (4) attempt to clarify the problem by stating, "it should be clearly realized that chronological age is not the real factor but that physiological age is the one that influences the capacity for exercise". At a recent symposium on the heart and physical exercise, Dr. I. Starr (5) pointed out that:

When one considers the evidence concerning the effect of aging on velocity and acceleration of cardiac performance, the conclusion is irresistible that strength of heart declines as age advances. The heart tends to lose the fine co-ordination of its contraction as age advances.

No mention is made as to whether age is physiological or
chronological although as Barry (6) points out, "Biological aging is the progressive loss of functional capacity of an organism after it reaches reproductive maturity".

Numerous investigations have studied the response of various age groups to specific work tasks (7, 8, 9, 10, 11, 12, 13). These studies indicate that there is a progressive decline in the capacity to adjust to different work tasks as age increases.

A reduction in an individual's capacity for work as measured by the adjustment of the circulatory system has been shown by Felzone and Shock (14) and has been supported by other experiments (15, 16, 17). Larson (18) concluded that there is a progressive and uniform retrogression in physical fitness with an increase in chronological age. Decrements in cardiovascular fitness have been shown to relate to the onset of age as measured by progressive work task experiments.

The components of cardiovascular fitness have been studied by several noted physical educators (19, 20, 21). More recently Cureton and Sterling (22) concluded that the pressure pulse wave, post-exercise or recovery pulse counts, and blood pressure measurements are important indices of cardiovascular fitness. The authors point out that there must be cautious interpretation of these indices because "full agreement cannot always be reached from either the physiological or psychological point of view" (23).

The measurement of blood pressure - systolic and diastolic, has been used as an indicator of improved cardiovascular fitness for some time. Cureton (24) states that the unfit person usually has a resting
systolic blood pressure below 90 mm. Hg. and over 160 mm. Hg. whereas a normal healthy man has a relatively high diastolic blood pressure in lying, sitting and standing positions; both are fairly good indicators of condition.

Henry (25) studied thirty male students before and after a season of competitive athletics and concluded that there was a significant decrease in systolic and diastolic blood pressures. Turner (26) found that a high systolic blood pressure in association with a relatively low diastolic blood pressure results in a wide pulse pressure which prevents circulatory stagnation in the splanchnic region. According to Dawson (27) the systolic blood pressure rose more rapidly and much higher in the trained than in the untrained. However, the author noted the absence of any conspicuous or constant effect of training upon systolic and diastolic pressures at least when exercise is moderate as represented by his experiments. Cogswell et. al. (28) noted an overall decrease in both systolic and diastolic blood pressures as a result of training. Using adult industrial workers Brouha (29) indicated that there was a decrease in the pulse pressure as a result of a diminished systolic blood pressure or by an increase in the diastolic blood pressure or both. He further stated that when the blood pressure had returned to the pre-exercise level, recovery was complete. The research study of Michael and Gallon (30) reported decreased systolic and diastolic blood pressures as a result of a four month training program.

Fraser and Chapman (31) contend that there is agreement in the research data that the systolic blood pressure does increase but there
is less agreement concerning the corresponding changes in diastolic pressure.

Christensen (32), Simonson and Enzer (33) report that the diastolic blood pressure either remains constant or increases slightly whereas Stevenson (34) found a reduction in the diastolic pressure two, three and five minutes after cessation of exercise. However, "the physiological significance of pressure changes during recovery are poorly understood but undoubtedly complex" (35).

Norris et al (36) found that the systolic blood pressure levels were higher in older subjects than in young people while the diastolic blood pressure levels were similar. Further, the older subjects increased their systolic blood pressure levels more after exercise and returned more slowly to pre-exercise levels. Only one conflicting point of view negated the value of blood pressure as an indicator of circulatory adjustment to exercise (37).

Post-exercise blood pressures "are much more indicative of real capacity than the quiet blood pressures... they reflect the warm-up capacity or adjustability to hard exercise" (38). A summary of research related to blood pressure changes as a result of exercise is presented by two authors (39, 40).

The pulse pressure wave which has been standardized (41), reflects important aspects of circulatory condition (42). The systolic amplitude and diastolic amplitude of waves taken in lying, sitting and standing positions have shown to be good measures of circulatory fitness (43). The changes in the pulse pressure wave attributed to a
season of basketball resulted in significant changes in systolic amplitude, pulse wave area, and diastolic surge (44). Cureton and Massey (45) concluded that the pulse pressure wave measurements of the area under the curve, systolic amplitude, diastolic amplitude and diastolic surge increased with training whereas a decline in the pulse wave area and diastolic surge parallels fatigue. A more recent study indicates the area under the curve and systolic amplitude reflect improved cardiovascular fitness (46). An endurance program utilizing middle-aged men resulted in an increase in the areas of pulse wave, systolic amplitude and diastolic amplitude (47). Several other studies reinforce this conclusion (48, 49, 50, 51, 52).

Yarr (53), who utilized the pulse pressure wave as a measure reflecting improved cardiovascular fitness in track performance, concluded that four measures: diastolic surge, rest-to-work ratio, systolic blood pressure, and pulse pressure, showed improvement. A study on middle-aged men who participated in a nine week endurance training program, showed no significant changes in pulse pressure wave measurements (54) whereas the effect of circuit training on pulse pressure wave measurements resulted in significant changes in the area under the curve, systolic amplitude, dicrotic notch amplitude, diastolic time, rest-to-work ratio, pulse rate sitting, standing systolic amplitude and standing area under the curve (55). Scott (56) studied the effectiveness of a twice-weekly thirty minute 'physical conditioning class' on improving cardiovascular condition, and concluded that improvement in the area under the curve and rest-to-work ratio were statistically
significant.

Pulse rate is

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...the easiest and simplest way to check circulo-respiratory fitness... it does not represent, however, a complete test of circulo-respiratory fitness but the pulse is the easiest to measure and is the most reliable of the physiological variables which reflect the internal bodily efficiency in response to exercise (56).

Taylor (57) concurs by stating "the heart rate problem should be evoked upon as a sensitive indicator of the trend for adaptation to the exercise".

The quiet sitting pulse rate is a useful index as an indicator of circulatory adjustment, when interpreted before and after an exercise program. Changes in pulse rate attributed to alteration of posture, which assumes that any external influences upon heart rate are minimal, has also been used as an indicator of improved cardiovascular fitness. A reduction in the total beats per minute reflects improved fitness. As Rodahl (58) points out,

When a person is undergoing physical training his pulse rate declines as his state of training and fitness improves. What this actually means is that a fit person can do a given amount of work without having to increase his heart rate as much as an unfit person.

Heart rate increases between ten and sixteen beats, attributed to changes in posture, are indicative of good circulatory adjustment (59).

Heart rate is directly affected by circulatory changes such as dissipation of heat and the supply of oxygen to the muscles, and is therefore considered as an index of the fatigue resulting from muscular activity (60).

As a predictor of circulatory adjustment during submaximal work, pulse rate has been thoroughly investigated. Rowell et al (61) point
out the limitation of the capacity to perform aerobic work is dependent upon the combined capacity of the respiratory and cardiovascular systems to transfer oxygen to the working muscles. The relationship between heart rate and oxygen consumption has been thoroughly investigated (62, 63, 64, 65, 66).

The decline of the resting pulse rate as a result of a training program has been investigated on a number of occasions. All results indicate a slower post-exercise pulse rate as being indicative of improved circulatory fitness (67, 68, 69, 70, 71).

Pulse rate recovery after a specific work task has been studied by many workers in an attempt to relate the increase in pulse rate during exercise and the time taken for it to return to resting levels. When the total pulse recovery is lower after an exercise program than that recorded prior to the training program, the subject will be able to withstand the stress of the work task for a longer period of time. Cureton and Sterling (72), Morehouse and Tuttle (73), Michael and Gallon (74), Cureton and Phillips (75), Durnin et al (76) all indicate that the higher the recovery pulse count, usually over a two minute period, the poorer the adjustment to that work task. Rodahl (77) reinforces this point by stating that "the person who has the lowest pulse rate at a given work load is the fittest person". Maxfield and Brouha (78) conclude that

... for the individual the higher the pulse rate, the more slowly it returns to its resting level. Likewise, for a specific work load, the better the physical condition of the individual the smaller the increase in heart rate and the more rapid the return to its resting value.
The authors (79) in another study confirmed the validity of heart rate as an indicator of the physiological strain induced by work. Rechnitzer et al (80) noted that the recovery pulse counts of four male cardiac patients was lower after a training program than the recovery pulse of normal adults. In another study, non-athletes had higher recovery rates than athletes as a result of standardized work (81).

In order to determine the various working capacities in a group of individuals, various working intensities must be employed. As the work loads increase, the discrepancies will be accentuated. Pulse rate is roughly linear to the work load but as the work rate and work load become exhausting, as usually indicated by a heart rate of 170-200, the work load is said to be maximal (82, 83, 84, 85). Other studies indicate the following: the athlete is able to sustain a given work load at a much slower pulse rate (86); the pulse rate of middle-aged men at any given work task can be reduced by training (87); and the exercise pulse rate will gradually increase with the speed of the work. The speed of increase also affects the speed at which the pulse rate returned to normal (88).

Several investigators have studied the relationship between chronological age and pulse rate. Sheffield (89) noted a steady decline in heart rate with an increase in age, but also stated that the general effect of physical training is to decrease the heart rate although the maximum rate possible is not materially affected, rather the effort required to produce it is increased. Norris, Shock and Yiengst (90) further emphasize that after exercise the heart rate increased more and
reached post-exercise levels later in older subjects than in younger subjects. Further evidence emphasizes that as man becomes older his pulse rate recovery to a specific work task is slower than that of a younger person (91, 92).

The test-retest reliability of the pulse pressure wave has been studied by Willet (93), and Cureton (94), who concluded that when the testing was conducted on two consecutive days, the following reliability values were obtained:

<table>
<thead>
<tr>
<th>Measure</th>
<th>Willet</th>
<th>Cureton</th>
</tr>
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<tbody>
<tr>
<td>Diastolic Pulse Wave Amplitude</td>
<td>.818</td>
<td>.768</td>
</tr>
<tr>
<td>Systolic Pulse Wave Amplitude</td>
<td>.818</td>
<td>.909</td>
</tr>
<tr>
<td>Obliquity Angle</td>
<td>.757</td>
<td>.788</td>
</tr>
<tr>
<td>Area of a Single Cycle</td>
<td>.811</td>
<td>.864</td>
</tr>
<tr>
<td>Diastolic Surge</td>
<td>.783</td>
<td>.878</td>
</tr>
<tr>
<td>Work to Rest Ratio</td>
<td>.719</td>
<td>.640</td>
</tr>
<tr>
<td>Pulse Pressure</td>
<td>.818</td>
<td>.794</td>
</tr>
<tr>
<td>Pulse Rate</td>
<td>.928</td>
<td>.996</td>
</tr>
<tr>
<td>Systolic Blood Pressure</td>
<td>.808</td>
<td>.765</td>
</tr>
<tr>
<td>Dicrotic Notch Amplitude</td>
<td>.755</td>
<td>.823</td>
</tr>
<tr>
<td>Diastolic Blood Pressure</td>
<td>.764</td>
<td>.794</td>
</tr>
</tbody>
</table>

Meeland (95) determined the test-retest reliability to be very satisfactory when the heartometer is used by a trained operator. Cureton (96) outlines a number of reliability studies which have been conducted on the pulse pressure wave at the University of Illinois.

A reliability study of the pulse ratio test conducted by Henry and Farmer (97) did not resolve any conclusive results, whereas a study by Cureton (98) indicated the step test to be a reliable test with co-efficients of reliability between .87 and .95.

McCurdy and Larson (99) made a careful study of the reliability of the Schneider Index and found acceptable reliabilities for blood pressure
measurements. The systolic blood pressure reliability ranged from .718 to .952. McFarland and Huddleson (100) reported the reliability of the Schneider Index as .89 which was considerably better for the separate items constituting the Index: lying pulse (.79), standing pulse (.71), post-exercise pulse (.58), lying systolic blood pressure (.63), and standing systolic blood pressure (.51). Studies conducted on the reliability of the Schneider Index on over 800 university students indicated the following reliabilities for the test items (101):

<table>
<thead>
<tr>
<th>Item</th>
<th>Reliability</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pulse Rate Lying</td>
<td>.79</td>
</tr>
<tr>
<td>Pulse Rate Standing</td>
<td>.91</td>
</tr>
<tr>
<td>Pulse Rate Lying to Standing</td>
<td>.70</td>
</tr>
<tr>
<td>Pulse Rate, After 15&quot; Exercise</td>
<td>.60</td>
</tr>
<tr>
<td>Pulse Rate Change, Standing to Post-exercise</td>
<td>.58</td>
</tr>
<tr>
<td>Time for Pulse to Recuperate to Standing Rate</td>
<td>.80</td>
</tr>
<tr>
<td>Lying Systolic Blood Pressure</td>
<td>.85</td>
</tr>
<tr>
<td>Standing Systolic Blood Pressure</td>
<td>.82</td>
</tr>
</tbody>
</table>

Morehouse and Tuttle (102) demonstrated that the reliability of the pulse rate after exercise was better when the exercise was relatively more strenuous.

<table>
<thead>
<tr>
<th>Steps</th>
<th>Reliability</th>
</tr>
</thead>
<tbody>
<tr>
<td>20</td>
<td>.070</td>
</tr>
<tr>
<td>30</td>
<td>.205</td>
</tr>
<tr>
<td>40</td>
<td>.720</td>
</tr>
<tr>
<td>50</td>
<td>.781</td>
</tr>
</tbody>
</table>
REFERENCES


17. Simonson, loc. cit.


23. Ibid., p. 22.


35. Fraser, Chapman, op. cit., p. 197.


70. Dawson, op. cit., p. 460.


75. Cureton, Phillips, op. cit., p. 89.


77. Rodahl, op. cit., p. 29.


86. Cumming, *op. cit.*, p. 82.


CHAPTER III

METHODS AND PROCEDURES

Subjects

Ten male subjects who voluntarily participated in the Physical Fitness Program for Middle-Aged Men at The University of British Columbia were chosen on the basis of regular attendance in the previous year's program. The age range was from twenty-seven to fifty-one years. All subjects were employed in a professional capacity either as a Faculty or a Staff member.

Training Program

In September, 1964, a mimeographed brochure (1) was sent to all Faculty and Staff members acquainting them with the fitness program which became operational in November, 1964. The sessions were conducted each day Monday through Friday from 12:30 P.M. to 1:30 P.M., excepting university holidays, in the New Education Gymnasium until April 2, 1965.

The initial sessions of the fitness program were generally informal and consisted of a warm-up period of approximately fifteen minutes during which time general calisthenics involving the use of ropes, medicine balls, benches, walking and flexibility exercises were combined in a non-stop rhythmical manner. As the general level of fitness improved, the emphasis was placed on endurance running in the gymnasium for a maximum of thirty minutes. Cross country running was emphasized in the spring when weather permitted going outside. One session, usually on Wednesday, was devoted to circuit training in the Memorial Gymnasium. At the conclusion of the thirty minute endurance exercise period, the
members of the fitness class participated in a game of volleyball for up to thirty minutes after which the hour was concluded with a shower.

Each session was conducted alternately by two members of the School of Physical Education Research Staff assisted by two graduate students.

The attendance roll was kept as efficiently as possible, although there can be no guarantee of absolute accuracy, since the class members themselves were sometimes responsible for checking the attendance list. Attendances were totalled for each subject and these totals were correlated with the improvement scores for each variable. The purpose of this procedure was to determine whether or not attendance was related to improvements in fitness.

Testing Procedures

1. Pre-training Tests

Each subject was tested individually and the measurements were recorded on the subject's fitness data sheet (see Appendix A). The subject arrived at the Fitness Laboratory according to a pre-arranged time, in a near basal state (see Appendix B), changed into his gymnasium dress and then rested for thirty minutes. After the rest period, the Schneider Test was administered (see Appendix C) and recorded (see Appendix D).

The subject was then tested with the Cameron Heartometer - the pulse pressure wave test. The pressure cuff was applied over the left brachial artery and the subject remained quiet sitting for three minutes, after which the tracings were completed sitting, standing
and after one minute run-in-place according to the directions outlined by the Cameron Heartometer Corporation (2) and by T.K. Cureton (3). One notable exception to the directions was used (see Appendices E and F).

At the conclusion of the Pulse Pressure Wave Test, the subject's body fat measurements and weight were recorded as outlined by Cureton (4).

The Progressive Pulse Ratio Test was completed at a pre-arranged time one week later as per the enclosed directions (see Appendix G).

The Schneider Test and the Pulse Pressure Wave Test were conducted between 7:00 A.M. and 9:30 A.M., whereas the Progressive Pulse Ratio Test was administered at a convenient pre-arranged time.

2. Post-training

The test times were identical for each subject on all tests. The same test procedures were followed as previously outlined. The fitness program, from pre-training to post-training, lasted seventeen weeks.

Measurements

The variables of the Pressure Pulse Wave were measured according to the directions as outlined in Cureton (5).

Calculations for the Schneider Test are outlined in Appendix C.

The plotting of the Progressive Pulse Ratio Test was completed as outlined in Appendix H.

Analysis of Data

The data collected from the three tests were analyzed on the
basis of a non-random, dependent sample as described by Ferguson (6).

The statistical method used was the 'Difference Method'. Garrett (7) 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 the initial and final performances.

The statistical treatment as outlined in Ferguson (8) was applied to each of the variables comprising the Schneider Test, Progressive Pulse Ratio Test, Pulse Pressure Wave Test, body fat measurements and body weight.

A one-tailed test with an arbitrarily chosen (.05) level of confidence was used. The t value for nine degrees of freedom was 1.833; if the t observed was greater than or equal to the table value of t, the result was considered significant.

A table was prepared showing co-efficients of correlation between improvements and the number of attendances for each subject.
REFERENCES


4. Ibid., p. 144.

5. Cureton, op. cit., pp. 235-250


CHAPTER IV

RESULTS

Ten male subjects, all Faculty and Staff members at The University of British Columbia, participated in a seventeen week endurance exercise program. Pre-training and post-training cardiovascular tests included the Schneider Test, the Progressive Pulse Ratio Test, and the Pulse Pressure Wave Test. Body fat and body weight were also measured.

The results of the study are summarized in Tables I, II, III, IV, V, VI under the headings of Pulse Pressure Wave Test, Body Fat, Body Weight, Progressive Pulse Ratio Test, Schneider Test, and Co-efficients of Correlation Between Number of Attendances and Improvement Scores. Using individual pre-training and post-training raw scores for all variables, the group means were calculated and tested for the significance of the difference using a one-tailed test with a five per cent level of confidence \((t^* = 1.833)\). The correlation co-efficients were tested for significance using a one-tailed test at the .05 level of confidence \((\gamma = .558)\).

**TABLE I**

THE SIGNIFICANCE OF THE DIFFERENCE BETWEEN INITIAL AND FINAL MEAN SCORES FOR EACH OF THE PULSE PRESSURE WAVE TEST VARIABLES

<table>
<thead>
<tr>
<th>Variable</th>
<th>(\bar{X}_I)</th>
<th>(\bar{X}_F)</th>
<th>(d)</th>
<th>(t)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sitting Area Under the Curve</td>
<td>0.314</td>
<td>0.361</td>
<td>0.047</td>
<td>1.153</td>
</tr>
</tbody>
</table>

(cont'd)
<table>
<thead>
<tr>
<th>Metric</th>
<th>Mean (I)</th>
<th>Mean (F)</th>
<th>d</th>
<th>t</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sitting Rest to Work Ratio</td>
<td>2.786</td>
<td>2.797</td>
<td>0.011</td>
<td>0.030</td>
</tr>
<tr>
<td>Sitting Systolic Time</td>
<td>0.275</td>
<td>0.276</td>
<td>-0.001</td>
<td>0.046</td>
</tr>
<tr>
<td>Sitting Diastolic Time</td>
<td>0.728</td>
<td>0.721</td>
<td>-0.007</td>
<td>0.165</td>
</tr>
<tr>
<td>Sitting Dicrotic Notch Amplitude</td>
<td>0.698</td>
<td>0.773</td>
<td>0.075</td>
<td>1.105</td>
</tr>
<tr>
<td>Sitting Fatigue Ratio</td>
<td>0.678</td>
<td>0.675</td>
<td>-0.003</td>
<td>0.047</td>
</tr>
<tr>
<td>Sitting Diastolic Amplitude</td>
<td>0.733</td>
<td>0.818</td>
<td>0.085</td>
<td>1.461</td>
</tr>
<tr>
<td>Sitting Obliquity Angle</td>
<td>22.290</td>
<td>22.080</td>
<td>-0.210</td>
<td>0.258</td>
</tr>
<tr>
<td>Sitting Pulse Rate</td>
<td>59.800</td>
<td>55.600</td>
<td>-4.200</td>
<td>2.436*</td>
</tr>
<tr>
<td>Sitting Systolic Amplitude</td>
<td>1.048</td>
<td>1.211</td>
<td>0.163</td>
<td>1.322</td>
</tr>
<tr>
<td>Sitting Systolic Blood Pressure</td>
<td>116.400</td>
<td>112.300</td>
<td>-4.100</td>
<td>2.088*</td>
</tr>
<tr>
<td>Sitting Diastolic Blood Pressure</td>
<td>75.500</td>
<td>69.300</td>
<td>-6.200</td>
<td>1.550</td>
</tr>
<tr>
<td>Sitting Pulse Pressure</td>
<td>44.800</td>
<td>43.000</td>
<td>-1.800</td>
<td>0.678</td>
</tr>
<tr>
<td>Standing Area Under the Curve</td>
<td>0.295</td>
<td>0.356</td>
<td>0.061</td>
<td>2.397*</td>
</tr>
<tr>
<td>Standing Pulse Rate</td>
<td>66.800</td>
<td>61.800</td>
<td>-5.000</td>
<td>2.677*</td>
</tr>
<tr>
<td>Standing Systolic Amplitude</td>
<td>1.044</td>
<td>1.097</td>
<td>0.053</td>
<td>0.669</td>
</tr>
</tbody>
</table>

(cont'd)
Table I indicates significant changes occurred in sitting pulse rate ($t = 2.436$), sitting systolic blood pressure ($t = 2.088$), standing area under the curve ($t = 2.397$), and standing pulse rate ($t = 2.677$) at the five per cent level of confidence.

**Table II**

**The Significance of the Difference Between Initial and Final Mean Scores for Each of the Body Fat Variables**

<table>
<thead>
<tr>
<th>Variable</th>
<th>$\bar{X}_I$</th>
<th>$\bar{X}_F$</th>
<th>$d$</th>
<th>$t$</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cheek Fold</td>
<td>9.600</td>
<td>10.000</td>
<td>0.400</td>
<td>0.768</td>
</tr>
<tr>
<td>Abdominal Fold</td>
<td>14.700</td>
<td>12.650</td>
<td>-2.050</td>
<td>1.836*</td>
</tr>
<tr>
<td>Hip Fold</td>
<td>17.100</td>
<td>14.650</td>
<td>-2.450</td>
<td>1.114</td>
</tr>
<tr>
<td>Front Thigh Fold</td>
<td>13.200</td>
<td>9.800</td>
<td>-3.400</td>
<td>3.285*</td>
</tr>
<tr>
<td>Rear Thigh Fold</td>
<td>10.500</td>
<td>8.050</td>
<td>-2.450</td>
<td>1.307</td>
</tr>
<tr>
<td>Gluteal Fold</td>
<td>21.400</td>
<td>16.750</td>
<td>-4.650</td>
<td>4.131*</td>
</tr>
<tr>
<td>Sum of All</td>
<td>86.500</td>
<td>72.050</td>
<td>-14.450</td>
<td>2.883*</td>
</tr>
<tr>
<td>Average of All</td>
<td>14.416</td>
<td>12.031</td>
<td>-2.385</td>
<td>2.836*</td>
</tr>
</tbody>
</table>

* Significant at the .05 level
Table II indicates significant changes occurred in abdominal fold \((t = 1.836)\), front thigh fold \((t = 3.285)\), gluteal fold \((t = 4.131)\), sum of all \((t = 2.883)\) and the average of all \((t = 2.836)\) at the five per cent level of confidence.

**TABLE III**

THE SIGNIFICANCE OF THE DIFFERENCE BETWEEN INITIAL AND FINAL MEAN SCORES FOR BODY WEIGHT

<table>
<thead>
<tr>
<th>Variable</th>
<th>(\bar{x}_I)</th>
<th>(\bar{x}_F)</th>
<th>d</th>
<th>t</th>
</tr>
</thead>
<tbody>
<tr>
<td>Body Weight</td>
<td>168.625</td>
<td>168.375</td>
<td>-0.250</td>
<td>0.172</td>
</tr>
</tbody>
</table>

Table III indicates the mean body weight of the group decreased 0.250 pounds. The mean difference was not significant at the five per cent level of confidence.

**TABLE IV**

THE SIGNIFICANCE OF THE DIFFERENCE BETWEEN INITIAL AND FINAL MEAN SCORES FOR EACH OF THE PROGRESSIVE PULSE RATIO TEST VARIABLES

<table>
<thead>
<tr>
<th>Variable</th>
<th>(\bar{x}_I)</th>
<th>(\bar{x}_F)</th>
<th>d</th>
<th>t</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total Recovery Pulse Counts 12 Steps</td>
<td>134.000</td>
<td>135.800</td>
<td>1.800</td>
<td>0.327</td>
</tr>
<tr>
<td>Total Recovery Pulse Counts 18 Steps</td>
<td>144.600</td>
<td>141.900</td>
<td>-2.700</td>
<td>0.567</td>
</tr>
<tr>
<td>Total Recovery Pulse Counts 24 Steps</td>
<td>151.700</td>
<td>156.800</td>
<td>5.100</td>
<td>0.896</td>
</tr>
</tbody>
</table>

(cont'd)
Table IV indicates that no significant changes occurred at the five per cent level of confidence in any of the recovery pulse counts for 12, 18, 24, 30 and 36 steps per minute. No significant change occurred in the average ratio and the average angle at the five per cent level of confidence.

**TABLE V**

THE SIGNIFICANCE OF THE DIFFERENCE BETWEEN INITIAL AND FINAL MEAN SCORES FOR EACH OF THE SCHNEIDER TEST VARIABLES

<table>
<thead>
<tr>
<th>Variable</th>
<th>$\bar{X}_I$</th>
<th>$\bar{X}_F$</th>
<th>d</th>
<th>t</th>
</tr>
</thead>
<tbody>
<tr>
<td>Index Score</td>
<td>16.500</td>
<td>16.400</td>
<td>0.100</td>
<td>0.015</td>
</tr>
<tr>
<td>Lying Systolic Blood Pressure</td>
<td>115.300</td>
<td>112.300</td>
<td>-3.000</td>
<td>1.686</td>
</tr>
<tr>
<td>Standing Systolic Blood Pressure</td>
<td>118.900</td>
<td>117.500</td>
<td>-1.400</td>
<td>0.517</td>
</tr>
<tr>
<td>Difference Between Lying and Standing Systolic Blood Pressure</td>
<td>7.600</td>
<td>6.600</td>
<td>-1.000</td>
<td>0.457</td>
</tr>
<tr>
<td>Difference in Pulse Rate Standing Immediately Following Exercise</td>
<td>15.400</td>
<td>14.000</td>
<td>-1.400</td>
<td>0.399</td>
</tr>
</tbody>
</table>

(cont'd)
Difference in Pulse Rate Lying to Standing

<table>
<thead>
<tr>
<th>Variable</th>
<th>$\bar{x}_I$</th>
<th>$\bar{x}_F$</th>
<th>d</th>
<th>t</th>
</tr>
</thead>
<tbody>
<tr>
<td>Time for Pulse to Return to Standing Value</td>
<td>78.000</td>
<td>54.000</td>
<td>-24.000</td>
<td>2.058*</td>
</tr>
<tr>
<td>Immediate Post-Exercise Pulse Rate</td>
<td>80.000</td>
<td>79.400</td>
<td>-0.600</td>
<td>0.156</td>
</tr>
<tr>
<td>Standing Pulse Rate</td>
<td>64.600</td>
<td>66.200</td>
<td>1.600</td>
<td>0.529</td>
</tr>
<tr>
<td>Lying Pulse Rate</td>
<td>57.200</td>
<td>55.200</td>
<td>-2.000</td>
<td>0.736</td>
</tr>
</tbody>
</table>

*Significant at the .05 level

Table V indicates only one variable, time for pulse to return to standing value ($t = 2.058$), was significant at the five per cent level of confidence.

TABLE VI

CO-EFFICIENTS OF CORRELATION BETWEEN NUMBER OF ATTENDANCES AND 'IMPROVEMENT' SCORES

<table>
<thead>
<tr>
<th>Variable</th>
<th>Correlation with Attendance</th>
<th>Variable</th>
<th>Correlation with Attendance</th>
</tr>
</thead>
<tbody>
<tr>
<td>Schneider Index Test</td>
<td></td>
<td>Progressive Pulse Ratio Test</td>
<td></td>
</tr>
<tr>
<td>Index Score</td>
<td>+0.007</td>
<td>Total Recovery Pulse Counts 18 Steps</td>
<td>+0.238</td>
</tr>
<tr>
<td>Difference Between Lying and Standing Systolic Blood Pressure</td>
<td>+0.383</td>
<td>Total Recovery Pulse Counts 18 Steps</td>
<td>-0.254</td>
</tr>
<tr>
<td>Standing Systolic Blood Pressure</td>
<td>+0.131</td>
<td>Total Recovery Pulse Counts 24 Steps</td>
<td>-0.234</td>
</tr>
</tbody>
</table>

(cont'd)
<table>
<thead>
<tr>
<th>Correlation with Attendance</th>
<th>Correlation with Attendance</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lying Systolic Blood Pressure</td>
<td>Total Recovery Pulse Counts 30 Steps</td>
</tr>
<tr>
<td>Difference in Pulse Rate Lying to Standing</td>
<td>Total Recovery Pulse Counts 36 Steps</td>
</tr>
<tr>
<td>Difference in Pulse Rate Standing Immediately Following Exercise</td>
<td>Average Ratio</td>
</tr>
<tr>
<td>Time for Pulse to Return to Standing Value</td>
<td>Average Angle</td>
</tr>
<tr>
<td>Immediate Post-Exercise Pulse Rate</td>
<td>Body Fat Measurements</td>
</tr>
<tr>
<td>Standing Pulse Rate</td>
<td>Body Weight</td>
</tr>
<tr>
<td>Lying Pulse Rate</td>
<td>Cheek Fold</td>
</tr>
<tr>
<td>   </td>
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</tbody>
</table>

(cont'd)
<table>
<thead>
<tr>
<th>Variable</th>
<th>Correlation with Attendance</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Pulse Pressure Wave Test</strong></td>
<td></td>
</tr>
<tr>
<td>Sitting Area Under Curve</td>
<td>-0.189</td>
</tr>
<tr>
<td>Sitting Rest/Work Ratio</td>
<td>+0.312</td>
</tr>
<tr>
<td>Sitting Systolic Time</td>
<td>-0.425</td>
</tr>
<tr>
<td>Sitting Diastolic Time</td>
<td>+0.216</td>
</tr>
<tr>
<td>Sitting Dicrotic Notch Amplitude</td>
<td>-0.001</td>
</tr>
<tr>
<td>Sitting Fatigue Ratio</td>
<td>-0.247</td>
</tr>
<tr>
<td>Sitting Diastolic Amplitude</td>
<td>-0.059</td>
</tr>
<tr>
<td>Sitting Angle of Obliquity</td>
<td>-0.435</td>
</tr>
<tr>
<td>Sitting Pulse Rate</td>
<td>-0.437</td>
</tr>
<tr>
<td>Sitting Systolic Blood Pressure</td>
<td>+0.158</td>
</tr>
<tr>
<td>Sitting Diastolic Blood Pressure</td>
<td>-0.221</td>
</tr>
<tr>
<td>Sitting Pulse Pressure</td>
<td>+0.395</td>
</tr>
<tr>
<td>Sitting Systolic Amplitude</td>
<td>+0.213</td>
</tr>
<tr>
<td>Standing Area Under Curve</td>
<td>+0.206</td>
</tr>
<tr>
<td>Standing Pulse Rate</td>
<td>+0.024</td>
</tr>
<tr>
<td>Standing Systolic Amplitude</td>
<td>+0.261</td>
</tr>
<tr>
<td>Difference Between Systolic Amplitude Sitting and Standing</td>
<td>-0.099</td>
</tr>
<tr>
<td>Post-Exercise Systolic Amplitude</td>
<td>+0.147</td>
</tr>
</tbody>
</table>

* Significant at the .05 level

Table VI indicates only three variables, average ratio (0.639), hip fold (0.637) and front thigh fold (0.631) were significant at the five per cent level of confidence.
CHAPTER V

DISCUSSION OF RESULTS

Significant improvements were made in only ten variables of forty-four used in this study. Significant changes at the five per cent level of confidence ($t = 1.833$) were observed in the following body fat measurements: abdominal fold, front thigh fold, gluteal fold, sum of all and average of all. Four variables of the Pulse Pressure Wave Test were significant, namely, sitting pulse rate, sitting systolic blood pressure, standing area under the curve and standing pulse rate. One variable, time for the pulse to return to standing value, of the Schneider Test was significant.

For each test variable, only the significance of the difference was tested between the pre-training and post-training tests. No analysis of individual improvement is considered for each test variable.

No specific reliability tests were carried out in this study. Previous investigators have found all variables to be quite reliable and it was assumed they were reliable in this study.

Subcutaneous fat was reduced as a result of the exercise program. Rechnitzer (1) has shown a significant reduction in body fat in cardiac patients as a result of physical exercise. Similarly a reduction in body fat was found to be associated with a hard training program (2). Though changes in five variables of body fat were statistically significant, body weight did decline but this was not significant at the .05 level of confidence. Brozek (3) and others have found that physical training does reduce body weight. Since fat free weight and
lean body mass were not determined, it is difficult to construct any logical conclusion as to the reason why the changes in body weight did not parallel the changes in the body fat measurements.

Research has shown that a slower post-exercise rate is indicative of improved circulatory fitness \((4, 5)\). When the heart rate is reduced "a fit person can do a given amount of work without having to increase his heart rate as much as an unfit person" \((6)\). With training there is a small but consistent reduction in the resting heart rate \((7)\).

The postural change of the body as reflected by a small increase in the heart rate sitting to standing may be interpreted as a favorable circulatory adjustment. Several studies indicate that the trained person's heart rate from sitting to standing is lower than the untrained. An increase of ten to sixteen beats per minute reflects a good circulatory adjustment \((8)\). However, Morehouse and Millar point out "its value as a component of physical fitness is very doubtful" \((9)\).

A resting systolic blood pressure below 90 mm. Hg. and over 160 mm. Hg. may be associated with an unfit person \((10)\). A significant reduction in the systolic blood pressure as a result of training has been noted in a number of experiments \((11, 12)\). However, it is interesting to note that the lying systolic blood pressure of the Schneider Test was not statistically significant at the \(0.05\) level of confidence, whereas the sitting systolic blood pressure of the Pulse Pressure Wave Test was significant. No explanation can be advanced for this difference.

A statistically significant increase in the standing area under the curve of 0.063 square centimetres was obtained. According to Cureton
and Sterling (13) the standing area of the pulse wave has a factor loading of .62 associated with the component blood ejection velocity proportional to the pulse wave. The authors have also noted "...that some large waves are associated with a slow pulse rate...." (14). The fact that the standing pulse rate showed a significant decrease at the .05 level may have some bearing upon the increase of the standing area under the curve being significant at the .05 level of confidence.

The adaptation of the body to the performance of a specific work load is dependent somewhat upon the individual's state of training. The changes observed in the performance of a cardiovascular test must bear some relationship to the type of training program used and is indicative of the effect of the specific type of training upon cardiovascular fitness. If this premise is correct, the fact that only five of thirty-six cardiovascular variables improved significantly, leads to the conclusion that the program was insufficient to produce a general improvement in cardiovascular condition. The frequency of participation by the subjects was neither uniform nor consistent and this may have played a decisive role in producing the small number of statistically significant cardiovascular variables (15). Rodahl (16) points out:

It does not take more than a couple of half-hour training sessions a week... to materially improve the maximal work capacity within a month.... the exercise must be sufficiently intense to increase the heart rate to more than 130 beats per minute. Experience has shown that when training activity is less vigorous than that, no improvement in physical work capacity occurs.

The possibility that the training program did not produce the stimulus of exercise heart rate of 130 beats per minute or more with sufficient
frequency may have been the important factor in producing a large number of non-significant results in the cardiovascular variables. A greater degree of improvement might have been possible had the subjects participated on a more regular basis. To substantiate this point of view, the average attendance of the group was 1.74 sessions per week which represents in total approximately thirty-nine per cent actual attendance of the possible total attendance. There may be a variety of reasons why the subjects did not come but there was no single overriding reason why the subjects came infrequently.

The recovery pulse rate parallels the intensity of the work task (17). Rowell states (18):

...the emotional state of the subject... the degree of physical conditioning, elapsed time after the previous meal, total circulating hemoglobin, the degree of hydration of the subject, alterations in the ambient temperature, and hydro-statically induced changes resulting from prolonged erect posture...

will affect the performance of an individual during a submaximal work task. With the possible exception of thirty-six steps per minute, which may be assumed to approach a maximal work task, the tests used were submaximal and according to Rowell subject to the aforementioned factors. However, only the emotional factor and the degree of physical training can be considered as possible factors affecting this study. Astrand and Ryhming (19) suggest that:

When testing circulatory-respiratory fitness a type of work must be chosen which engages large groups of muscles and the level of work must be relatively high. The duration of the work must be long enough to permit the adjustment of circulation and ventilation to the level of exercise usually requiring five to six minutes.

Hypothetically, then, the tests utilized were not difficult enough nor
long enough to permit the subject to attain a 'steady state' which is noted as a pulse rate between 125 and 170 beats per minute (20). Wahlund (21) suggests that a number of work tasks of increasing intensity should be incorporated in the determination of the physical work capacity of the individual. These discrepancies between individual members of a group will be accentuated when work tasks are increased. As pointed out earlier, the actual working time employed in a test is often too short for reliable determinations of submaximal work capacity. Andersen (22) substantiates this by stating:

The duration of the exercise at submaximal rates should be 8-10 minutes, the respiratory and circulatory measurements being taken during the last minutes, after the subject has reached a "steady state".

The emotional state of the subject may, as pointed out by Hickam (23), "have a profound effect on the circulation causing changes in the heart rate". This point of view is substantiated by Brouha and Radford (24) and Henderson (25). Faulkner (26) adds support to this premise by stating:

Human subjects respond to an unknown minimal work intensity with an increased heart rate in anticipation and an overshoot in heart rate during the initial stages to adjustment to exercise.

On the basis of this opinion, the initial pulse ratios could have been affected by the subject's pulse rate rising rapidly prior to and during the lower work loads thereby causing succeeding pulse ratios at the higher work rates to be distorted. Morehouse and Tuttle (27) state that the pulse ratio test is subject to certain problems:
The reliability of the pulse rate for two minutes after exercise is directly related to the strenuousness of the exercise. Thus, if the response of the heart is to be measured, the exercise must be strenuous enough (40-50 steps/minute) to overshadow environmental stimuli which affect the pulse rate after light exercise (20-30 steps/minute) to such an extent that successive readings are unreliable.

There was some considerable variation in the number of attendances made by the subjects, i.e. attendances ranged from 17 to 45 with a median of 30.5. It was considered possible, therefore, that the number of attendances might have had a direct relationship to the amount of change made by individual subjects between tests. This assumption was tested by correlating attendance with the differences between test one and test two scores. The hypothesis that the correlation co-efficient was significantly different from zero was tested in each instance by the conventional statistical method using a one-tailed test at the .05 level of confidence.

It was apparent that a 'direct' relationship between attendance and improvement would, in some instances, produce a correlation with a negative sign and in other instances a correlation with a positive sign. This was taken into account when applying the one-tailed test to each correlation co-efficient.

Only three correlation co-efficients were of sufficient size to be considered significantly different from zero. These were the co-efficients of correlation between attendance and average pulse ratio (0.639), front thigh fat fold (0.631) and rear thigh fat fold (0.637). With the exception of the average pulse ratio, none of the correlations between the cardiovascular variables and attendance approached
significance. The values of these co-efficients ranged from 0.001 to 0.637 with a median of 0.240. The remaining six of the eight correlations between fat measurements and attendance ranged from 0.042 to 0.421, with a median value of 0.306. There was no relationship between loss of body weight and number of attendances by the subjects.

It is apparent that individual differences in improvement of cardiovascular condition were not related to attendance. It is obvious, therefore, that failure to show significant differences between mean scores of the majority of variables cannot be attributed to a high variability in the attendance record of the group of ten subjects. It seems reasonable, therefore, that any search for possible explanations why the majority of variables did not show significant mean improvements must be directed elsewhere. There are several other possible reasons: the submaximal tests may have not been sufficiently reliable to yield stable results; the subjects on the whole may not have participated sufficiently frequently nor intensively in order to make adequate improvements in cardiovascular condition; the variables may not have been sufficiently sensitive to show the changes which did occur as a result of the subjects' participation in the exercise program.
REFERENCES


CHAPTER VI
SUMMARY, CONCLUSIONS AND RECOMMENDATIONS

Summary

The purpose of this study was to evaluate the effects of an endurance exercise program upon cardiovascular variables of a group of middle-aged men. Ten subjects, all faculty and staff members of the university, participated voluntarily in the Physical Fitness Program for Middle-Aged Men at The University of British Columbia. Each subject was tested before and after participation in a seventeen week program.

The pre-training and post-training test environments and test procedures were standardized for all subjects. A basal condition instruction sheet (see Appendix B) was sent to all subjects.

The tests were conducted according to the enclosed appendices and based upon previous investigations.

Each subject arrived at the Fitness Laboratory in a near basal state, changed into his gymnasium dress and then rested for thirty minutes. The Schneider Test was administered first after the thirty minute rest followed by the Pulse Pressure Wave Test. Tracings were completed in the sitting, standing and after one minute run-in-place. At the conclusion of the pulse wave test, the subject's body fat measurements and weight were recorded. The Progressive Pulse Ratio Test was completed on a second occasion one week later.

The pre-training - post-training raw scores for all variables were analyzed on the basis of the significance of the difference between group mean scores using a .05 level of confidence. The following
variables were tested:

(1) **Schneider Test**

Variables are: lying pulse rate, standing pulse rate, post-exercise pulse rate, time for pulse to return to standing value, difference between pulse rate lying to standing, and standing to post-exercise difference, lying and standing systolic blood pressure and the difference between systolic blood pressure lying and standing.

(2) **Progressive Pulse Ratio**

Variables: recovery pulse counts for rates of 12, 18, 24, 30 and 36 steps per minute, average ratio and average angle.

(3) **Pulse Pressure Wave (Brachial Sphygmmograph)**

Variables are:

A. **Sitting**

area under curve, systolic amplitude dicrotic notch amplitude, fatigue ratio, diastolic amplitude, rest to work ratio, obliquity angle, systolic time, diastolic time, pulse rate, systolic blood pressure, diastolic blood pressure and pulse pressure.

B. **Standing**

area under curve, pulse rate, systolic amplitude, difference between sitting and standing systolic amplitude.

C. **Post Exercise**

systolic amplitude

(4) **Body Fat Measurements**

Variables are: cheek fold, abdominal fold, hip fold, front thigh fold, gluteal fold, rear thigh fold, sum of all, and average.
(5) Body Weight

The results of this study show the following: the mean body fat measurements - abdominal fold, front thigh fold, gluteal fold, sum of all and average of all - decreased at the .05 level of confidence.

Significant changes at the .05 level of confidence were observed in four of eighteen variables of the Pulse Pressure Wave Test. The variables were sitting pulse rate, sitting systolic blood pressure, standing area under the curve and standing pulse rate. Only one variable of the Schneider Test - time for pulse to return to standing value - was significant at the .05 level of confidence.

No significant changes were observed at the .05 level on any of the seven variables of the Progressive Pulse Ratio Test.

Improvement scores for all variables were correlated with the number of attendances made by the subjects. Only three variables - average pulse ratio, front thigh fat fold, rear thigh fat fold - had co-efficients of correlation with attendance which were sufficiently large to be considered statistically significant from zero.

Conclusions

The results of the study show the exercise program was capable of producing reduction in fat measurements without concomitant loss of body weight but that there were few significant mean improvements in the cardiovascular measurements used. The significant mean improvements were almost exclusively in those variables measuring resting heart rate.

The failure to show significant mean improvements in the majority
of cardiovascular measurements was not related to the variability in frequency of attendance of the individual subjects. It seems likely, therefore, that the failure to show significant mean improvements in cardiovascular condition was due to one or more of the following reasons: the submaximal tests may not have been sufficiently reliable; the subjects as a group may not have participated sufficiently frequently or intensively; the variables may not have been sufficiently sensitive to reflect the changes which did occur as a result of the exercise program.

Recommendations

The following recommendations seem justified on the basis of the results obtained in this study. Future studies involving the use of middle-aged men should incorporate the following points in the overall design of the study, namely: a control group, the case study approach, the use of non-parametric statistical analysis, thorough medical examination for each subject prior to engaging in the study, test-retest reliability check of the measuring instruments and an accurate record of compulsory attendance for all subjects.
BIBLIOGRAPHY

BOOKS


**PERIODICALS**


UNPUBLISHED MATERIAL


APPENDIX A

FITNESS DATA SHEET

NAME: ________________________
AGE: ________________________ yrs.

I. Anthropometric Measurements

Height: ___________ inches
Weight: ___________ lbs.

II. Body Fat Measurements

Date: ________________________
Tester: ________________________
1. Cheek Fold ___________ mm
2. Abdominal Fold ___________ mm
3. Hip Fold ___________ mm
4. Front Thigh Fold ___________ mm
5. Gluteal Fold ___________ mm
6. Rear Thigh Fold ___________ mm
Sum of All ___________ mm
Average ___________ mm

III. Schneider Index

Date: ________________________
Tester: ________________________
(15 sec.count) (beats/min)
Lying Pulse Rate ___________ x 4 = ___________
Standing Pulse Rate ___________ x 4 = ___________
Immediate Post Exercise Pulse Rate ___________ x 4 = ___________
Time for Pulse Rate to return to standing value ___________ min ___________ sec
Difference in Pulse Rate lying to standing ___________ x 4 = ___________
Difference in Pulse Rate standing to immediately following exercise ___________ x 4 = ___________
Lying Systolic Bp ___________ mm. Hg.
Standing Systolic Bp ___________ mm. Hg.
Difference between lying and standing Bp ___________ mm. Hg.
Schneider Index ___________

IV. Progressive Pulse Ratio

Date: ________________________
Tester: ________________________
(30 sec.count) (BPM)
Initial Pulse Rate
Sitting ___________ x 2 = ___________

Recovery Pulse Counts (2 minutes)
Steps per minute Recovery Counts
12 ___________ = ___________
18 ___________ = ___________
24 ___________ = ___________
30 ___________ = ___________
36 ___________ = ___________
Pulse Ratios
12 ___________ = ___________
18 ___________ = ___________
24 ___________ = ___________
30 ___________ = ___________
36 ___________ = ___________
Average Ratio = ___________
Average Angle = ___________

V. Heartometer

Date: ________________________
Tester: ________________________
Sitting
Area _______ Cycle T. _______
Sys.Amp. _______ Sys. T. _______
Dia.N.Amp. _______ Dia. T. _______
F. Ratio _______ Pulse R. _______
Dia. Amp. _______ Sys.B.p. _______
R/W Ratio _______ Dia.B.p. _______
Dbl.Angle _______ P.Press. _______

Standing
Area _______ Pulse R. _______
Sys.Amp. _______ _______
Diff.Betw.Amp.Sitt. & Stand. _______
Post Exercise
Ampl. _______
DIRECTIONS FOR PREPARING FOR TESTS
TO BE DONE UNDER BASAL CONDITIONS

I. Evening before the test:--

1. Eat a light dinner.
2. Spend the evening quietly.
3. Use no stimulants after the evening meal, (i.e. coffee, tea, cokes, tobacco, alcoholic beverages). If you are taking any medication, inquire about its use before the test.
4. Retire early. Get at least eight or nine hours of sleep.

II. The morning of the test:--

1. Get up in time to complete preparations without hurrying.
2. Do not take a morning bath or shower. You may wash your face and hands.
3. Do not eat any breakfast or use any stimulants or drugs.
4. Do not take any exercise. You may walk short distances i.e. to your car or to the Fitness Laboratory. Walk slowly.
5. Arrive at the Physical Fitness Laboratory promptly at the appointed time.
6. Remove all tight articles of clothing such as: shoes, garters, collars, etc., and lie down on the bed and relax completely. Cover up sufficiently to be comfortable. Rest until the test is started. It is quite all right to fall asleep but not essential. Complete relaxation is important.

III. It is of the utmost importance to follow the preceding instructions if the results are to be reliable.

If you have a severe cold accompanied by marked congestion of the nose, coughing, or a fever, it is advisable to postpone the tests. Advise any cancellation of the appointment as early as possible.
APPENDIX C

INSTRUCTIONS FOR THE SCHNEIDER TEST

The numbers
Correspond with
Test Sheet.

1. The subject rests in the lying position on the back for five minutes
or more. If the pulse is above 70 after five minutes rest, the rest
in the horizontal position should continue for another five minutes
at least and then the pulse taken again. The lowest pulse should
be inserted on line 1 of the Schneider Score Sheet. Count is 15 secs.
multiplied by four for the count per minute.

2. The lying systolic blood pressure is taken with a mercurial
sphygmomanometer (see Deaver's Fundamentals of Physical Examination,
1939, pp. 216-224).

3. The lying diastolic blood pressure is taken in similar manner,
reading the sound at the 4th phase when there is noted a change in
sound from sharp and clear to muffled sounds. This is somewhat
higher on the scale than when the sounds disappear.

4. The subject is then asked to get up from the table easily and stand
on his feet. At this time the cuff is disconnected from the
instrument but not removed from the arm. The subject is also told
to hold his arm bent so that the cuff will not fall off. He must
remain in the relaxed standing position for at least one full
minute or two before the standing pulse rate can be taken.

5. The standing systolic blood pressure is taken with precautions that
the subject is standing on both feet and is in a relaxed state. A
word to the subject is helpful as a reminder to stand easily on both
feet and to relax.

6. The standing diastolic blood pressure is also taken, similarly to
lying diastolic.

7. The standard step-up is demonstrated as one step up and down in
3 secs., or 5 times in 15 secs. The subject is asked to step up
five times at that rate. The pulse is counted immediately after
for 15 secs. and put down on the data sheet as (15x4-60). This will
ensure that no error has been made by multiplying in the head.

8. Thirty seconds after the exercise the pulse is again counted for
15 secs. This is quickly recorded on the data sheet and compared
with the standing pulse. If it is higher than the standing pulse,
another count is taken at 90 and 120 seconds. On the count which
is even with or lower than the standing pulse, the procedure is
stopped and that pulse is placed in the corresponding time space
of the data sheet.
9. Each of the sections are scored: A, B, C, D, E, and F. The procedure is as follows:

(a) Section A is scored for reclining pulse rate. The best resting pulse rate is compared with the table in Section A and the points immediately after are rung.

(b) Section C is scored in like manner for the standing pulse rate.

(c) Section B is scored on the same line as previously rung for the lying pulse rate. It is important to stay on this same line as the amount of change is traced from left to right over to Table B. The amount of change from lying to standing pulse must be subtracted and matched with the headings of Table B. The points earned are rung in the body of the Table B. A pencil is used to encircle the points earned.

(d) Section D is scored in similar manner to Section B. It is important to stay on the same line as was used on scoring the standing pulse ratio. The horizontal line is traced from Table C to Table D horizontally across the page from left to right. The amount of pulse rise from the standing rate to the rate after exercise is noted by subtraction and this amount is matched with the table headings in D. The points earned are encircled in the body of Table D.

(e) The return of pulse rate to the standing normal is now scored, using Table E. The time for the pulse to return to the standing normal is noted and matched with Table E. The points earned are encircled.

(f) The change in systolic blood pressure is noted comparing the difference between the lying and standing pressures. The difference is scored in Table F. The points earned are encircled.

**Summation of Total Score (Schneider Index):**

This is obtained by adding up the points encircled in each of the six sections: A, B, C, D, E, F. This result is placed in the space provided, under TRIAL I. The date is inserted just above.

**Rechecks:**

It is recommended that a second or third check be taken by completely repeating the Schneider Test procedure. The index is very helpful if it is a reliable result. Some people are mentally excited on their first trial on this test and the pulse rate may be higher than is truly normal. The best of two or three trials is usually preferred as a most reliable result.

**Diastolic Blood Pressure:**

This should also be inserted although it is not used in the Schneider Test. A standing diastolic lower than 60 usually means poor endurance in long continued exertion, such as running or swimming. Good athletes range from 85 to 105 in standing diastolic blood pressure.


Systolic Blood Pressure:

It is usually recommended that any case with systolic blood pressure over 160 or lower than 80 should be referred to a physician for a more complete diagnosis. The pulse pressure (difference between the systolic and diastolic pressures) is used in several cardiovascular tests. This is usually noted. A pulse pressure above 40 indicates an untrained state. This may be the basis of referring the subject to a conditioning class.

Original Data Sheets:

The original data sheets should be saved because the data may be used in several ways in the research. The notations should be carefully made.
APPENDIX D

SCHNEIDER INDEX TEST - SCORE SHEET
(Cureton Modification)

<table>
<thead>
<tr>
<th>Name</th>
<th>Date</th>
<th>Schneider Index</th>
</tr>
</thead>
</table>

**OBSERVATIONS**

Lying Position: Pulse Rate ______ Systolic BP ______ Diastolic BP ______

Standing Position: Pulse Rate ______ Systolic BP ______ Diastolic BP ______

STEP EXERCISE (5 steps-chair 20" high): Pulse Rate Immediately After Exercise ______

Pulse Rate After Exercise: 30 sec. ______ 60 sec. ______ 90 sec. ______ 120 sec. ______

**SCORING TABLE**

<table>
<thead>
<tr>
<th>A. Reclining Pulse Rate</th>
<th>B. Pulse Rate Increase on Standing</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rate Points</td>
<td>0-10</td>
</tr>
<tr>
<td>41-50 4</td>
<td>4</td>
</tr>
<tr>
<td>51-60 3</td>
<td>3</td>
</tr>
<tr>
<td>61-70 3</td>
<td>3</td>
</tr>
<tr>
<td>71-80 2</td>
<td>2</td>
</tr>
<tr>
<td>81-90 1</td>
<td>2</td>
</tr>
<tr>
<td>91-100 0</td>
<td>1</td>
</tr>
<tr>
<td>101-110 -1</td>
<td>0</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>C. Standing Pulse Rate</th>
<th>D. Pulse Rate Increase Immediately After Exercise</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rate Points</td>
<td>0-10</td>
</tr>
<tr>
<td>51-60 4</td>
<td>4</td>
</tr>
<tr>
<td>61-70 3</td>
<td>3</td>
</tr>
<tr>
<td>71-80 3</td>
<td>3</td>
</tr>
<tr>
<td>81-90 2</td>
<td>2</td>
</tr>
<tr>
<td>91-100 1</td>
<td>2</td>
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<tr>
<td>111-120 0</td>
<td>1</td>
</tr>
<tr>
<td>121-130 0</td>
<td>0</td>
</tr>
<tr>
<td>131-140 -1</td>
<td>0</td>
</tr>
</tbody>
</table>

**E. Return of Pulse Rate to Standing Normal After Exercise**

<table>
<thead>
<tr>
<th>Seconds Points</th>
<th>Change in Millimeters</th>
<th>Points</th>
</tr>
</thead>
<tbody>
<tr>
<td>0 - 30</td>
<td>Rise 30 and more</td>
<td>-2</td>
</tr>
<tr>
<td>31-60</td>
<td>Rise 21 to 30</td>
<td>-1</td>
</tr>
<tr>
<td>61-90</td>
<td>Rise 16 to 20</td>
<td>0</td>
</tr>
<tr>
<td>91-120</td>
<td>Rise 11 to 15</td>
<td>1</td>
</tr>
<tr>
<td>AFTER 120</td>
<td>Rise of 6 to 10</td>
<td>2</td>
</tr>
<tr>
<td>2 - 10 beats</td>
<td>No change greater than 5</td>
<td>3</td>
</tr>
<tr>
<td>above normal</td>
<td>Fall of 6 to 10</td>
<td>2</td>
</tr>
<tr>
<td>AFTER 120</td>
<td>Fall of 11 to 15</td>
<td>1</td>
</tr>
<tr>
<td>11 - 30 beats</td>
<td>Fall of 16 to 20</td>
<td>0</td>
</tr>
<tr>
<td>above normal</td>
<td>Fall of 21 to 25</td>
<td>-1</td>
</tr>
<tr>
<td></td>
<td>Fall of 26 and more</td>
<td>-2</td>
</tr>
</tbody>
</table>

4/2/65
APPENDIX E

CONDENSED INSTRUCTIONS FOR BLOOD PRESSURE FINDINGS AND MAKING HEARTOGRAPHs

MODEL - 6100

FOLLOW THESE INSTRUCTIONS EXACTLY -- NO OTHER METHOD WILL FURNISH PROPER RESULTS.

1. Turn Heartometer so patient can't watch graph being made.

2. Cuff must be put on tight - snugness is important. (Instruct patient to remain quiet - they must not move or speak.)

3. Have clutch OUT - close air valve in inflation system.

DIASTOLIC

4. Inflate, pause - Inflate, pause - Inflate, pause - etc. (The pause should be for two or three seconds.) Continue inflating and pausing until one light (either) is flashed by the pulse. This is the DIASTOLIC point (5th phase). Push clutch in and mark diastolic pressure. Pull clutch all the way OUT stopping the graph.

5. Inflate quickly until you have fixed light (no flashing) = collapsed artery.

SYSTOLIC

6. Now, deflate, pause - deflate, pause - deflate, pause - etc. (The pause should be for two or three seconds.) Continue deflating and pausing until pulse flashes one (either) light for a count of 10.† This is the SYSTOLIC point. Push clutch in and mark systolic pressure. Pull clutch all the way OUT stopping the graph.

GRAPHING

7. Now, deflate until 10 or 15 mm. below diastolic mark. Stop! (Don't deflate to zero.) Now, increase the pressure above diastolic; 1/4 of the pulse pressure (usually 10 to 20 mm. above diastolic). Push clutch in to start motor; make Heartograph. Pull clutch all the way OUT stopping the graph. Release pressure from cuff promptly.

(†) When Skipped Beats, Fibrillation, etc. is present there can never be 10 successive pulses to actuate the lights. The term "COUNT
OF 10" is used to cover such cases. (Counts should be INTERVALS of 1 Second.)

(*) Exceptions to this rule are: In very low diastolic pressure or obliterated cases in the legs, one may have to make a short graph at different pressures in order to establish the proper graphing point.

CAMERON HEARTOMETER COMPANY

Chicago Illinois
The University of British Columbia
Vancouver 8, B.C., Canada.

November 23, 1964
Air-Mail.

Attention:  S.R. Brown, Associate Professor,
School of Physical Education & Recreation.

Gentlemen:

In reply to your letter of November 20, 1964, per enclosed condensed instructions, please note that when one light, (EITHER LIGHT) is flashed by the pulse, that is the correct diastolic and systolic level.

ALTERNATING LIGHTS, which sometimes take place in the pulse pressure field (between the diastolic and systolic levels) are of no diagnostic value.

In almost every case, difficulty or inability to obtain correct light action at either or both the diastolic and systolic levels is caused by the fact that the inflation system is not on tight and snug. This is very important. The inflation system cannot be put on too tight.

Also, on brachial (arm) findings, the Ace bandage should always be used over the inflation system cuff when the patient has a large flabby arm.

By dropping to zero after you have obtained and marked the systolic pressure level, you certainly are not following the correct established operating procedure.

DROP DOWN ONLY 10 to 15MM below the diastolic level and then stop. DO NOT DROP DOWN TO ZERO.

If you let out all pressure and then re-apply pressure, you will almost certainly obtain a decrease in graphing pressure which will appear to be a pressure loss from the inflation system. It is however nothing more than the muscle of the arm fighting the re-application of pressure.

By following the established procedure, if pressures are taken quickly and accurately (which only requires a minute) there can be no venous congestion and you need not worry about that factor entering the picture.

The procedure to re-engage the clutch, if necessary, to make the pen write in the correct position on the graph has always been mentioned in the Heartometer Technique Book. Latest book has the information on page 7. It states: "At times, the heart graph pen does not always graph at the same distance from the center of the chart. The position of the pen is dependent upon the engaging of the clutch at the beginning, middle or
end of the cardiac cycle. This has no real diagnostic significance. To change position of pen on chart, pull out clutch and re-engage. The graph on page 10 is an example of two tracings made at different positions on the paper".

A "sagging graph" is almost always caused because the correct procedure was not followed (all pressure was let out and then the Inf. system was re-inflated to graphing level).

However, neither of the above could be responsible for the failure of the lights to operate properly.

Further, if you are making all Heartographs at 80MM graphing pressure, you are ignoring the fact that pressures vary in individuals according to age, bio-type, weight, heredity and certainly environment. We have not nor do we intend to suggest that all graphs be taken at one pressure. We are not unmindful that (even in the apparent healthy) there is wide variation in pressures. It has been stated for many years and we repeat: Tell me where you were born, where your parents were born, and the environment one has or is passing through, and we should be able to closely evaluate the normal pressure.

Send us 1/2 dozen graphs that you have made (which will be returned to you) and we will attempt to supply additional information that will assist you.

We suggest that you return your unit for immediate repair. You cannot accurately check diastolic and systolic pressures with any mercury column and stethoscope with any real degree of accuracy. The average error in trying to use sounds is from plus 7MM to minus 7MM. Thus, the average error is 14MM. Also, few can properly identify the correct diastolic level (5th phase) that the Heartometer gives you for diastolic pressure. Fifth phase diastolic pressure is the only correct phase to use.

Very truly yours,
CAMERON HEARTOMETER CORP.

"Alex W. Cameron"

Alex W. Cameron, V.P.-Treas.

AWC/em.
APPENDIX G

SPECIFICATIONS FOR PROGRESSIVE PULSE RATIO TEST (STEPS OR SQUATS)

1. (a) Seat subject 5 Mins. Count sitting pulse for 30 secs.
   (b) After 30 secs., count sitting pulse for 30 secs. again.
   (c) If pulse is stable (± 1 beat), go on with the test. If not,
       count sitting pulse again and continue until two successive
       counts are the same. If there is still fluctuation, use the
       average.

2. Have the subject stand up. Count aloud the timing of the stepping
   at 5 seconds for each complete trip (12/min.), 2½ secs. UP and 2½
   secs. DOWN. Demonstrate. Ask the subject to count the number of
   trips he makes in one minute at 12/min. Start the subject on the
   even minute at the start of one revolution of the minute hand on a
   stop watch or suitable photo-timer. Count for the subject so that
   one complete trip coincides with 5 secs. on the clock. Continue
   stepping for exactly one minute. Tell the subject to sit down.
   Then after 10 secs. count pulse for 2 Min. i.e., begin the pulse
   count exactly 10 secs. after the even minute.

3. Compute the pulse ratio and plot the second point while the subject
   remains seated. Recheck the sitting pulse rate at least twice.
   Continue until the pulse is stable (± 1 beat) and record in terms
   of beats/min. Do not wait longer than 5 minutes after stepping. If
   pulse is not stable by the end of this period, count pulse, record,
   and continue stepping.

4. Count the rate of stepping at 3.33 secs. for one complete trip,
   18/min. Three trips in 10 secs. Demonstrate. Ask the subject to
   count the number of steps or use a pulse counter. Step the subject
   at this rate for exactly 1 minute. At the end, seat the subject
   and after 10 secs. count the pulse for 2 mins. Compute the pulse
   ratio and plot the point.

5. After 2 or 3 mins., check pulse at least twice for 15 secs. Continue
   until the pulse rate is stable. Record the sitting rate.

6. Explain the rate of stepping at 24 steps/min., 2½ secs. per trip.
   Demonstrate. Ask the subject to count his trips. Step the subject
   for exactly one min. Sit the subject down and after 10 secs., count
   the pulse for 2 mins.

7. Repeat step 5.

8. Explain to the subject the rate of stepping at 30/min. Demonstrate,
   one sec. UP and one sec. DOWN. Ask the subject to count the steps
   (dips). Step the subject for exactly one min. Sit the subject down
   and after 10 secs., count the pulse for 2 mins. Compute the pulse
   ratio and plot the 4th point.
9. Recheck the sitting pulse rate at least twice and continue until the pulse is stable. Record the sitting rate.

10. Explain the rate of stepping at 36/min. Demonstrate or count out three trips UP and DOWN in 5 secs. Ask the subject to count the number of steps and step the subject for exactly one minute.
APPENDIX H

INSTRUCTIONS FOR PLOTTING THE PROGRESSIVE PULSE RATIO

Graph Paper: 20 lines to the inch preferred. 1 inch squares in dark lines.

Preparation: Label graph at bottom margin - "Progressive Pulse Ratio". Write subject's name and the date of testing at the top of the graph. Draw ordinate (vertical axis) on one of the dark lines about one-half inch in from the left hand edge. Draw abscissa (horizontal axis) on one of the dark lines about two inches up from the bottom edge.

Mark the ordinate scale - 1.8, 2.0, 2.2, 2.4, 2.6, 2.8, 3.0, beginning with 1.8 at the junction of ordinate and abscissa, and working upwards at intervals of one inch. Label these 'Ratios'.

Mark the abscissa scale - 12, 18, 24, 30, 36, beginning with 12 at the junction of ordinate and abscissa and working along the abscissa to the right at intervals of one and one-half inches. Label these 'Steps per Minute'.

Label and record the pulse rates and ratios obtained as the test progresses.

Example:

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<tr>
<th>Steps per Min.</th>
<th>12</th>
<th>18</th>
<th>24</th>
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Pulse Rates:

2 MIN. POST EX. = 149 154 162 178 205
1 MIN. QUIET SIT = 74  74  74  76  76
RATIOS = 2.01 2.08 2.19 2.34 2.70

PROGRESSIVE PULSE RATIO

Procedure

1. Calculate the ratios as the test progresses. Plot the ratios on the graph and join the points by straight lines.
2. Calculate the average ratio - i.e. Sum the five ratios and divide by five. Plot this ratio on the graph directly above '24 steps per minute' on the abscissa scale. Draw a straight line between this point and the point at 2.0 on the ordinate scale. Project this line to the right side of the graph. Label the point - Average Ratio.

3. Measure the average angle. Measure, with a protractor, the angle at point 2.0 on the ordinate scale between the horizontal and the average ratio. Record the angle obtained, in degrees and half-degrees, on the graph and label - Average Angle.

4. Measure the following angles. Record the values on the graph in degrees and half-degrees.
   1. Angle at ratio for 24 steps per minute.
   2. Angle at ratio for 30 steps per minute.

One side of the angle is formed by the horizontal. The other side is formed by the plotted line joining the respective ratio and the next one to the right - i.e. 24 and 30 steps per minute; 30 and 36 steps per minute.

These angles measure the slope of the plotted lines and reflect the amount of increase in pulse counts as a result of increasing the rate of stepping.

5. Consult the standard score tables for the Progressive Pulse Ratio test. Write along side each of the raw measures the appropriate standard score. Enclose the standard score in parenthesis - i.e. (55), to ensure differentiation between raw scores and standard scores.

'Angle of Break'. Is the angle between the horizontal and the plotted line where it first breaks sharply upward from its previously fairly uniform slope.

'Angle of Inclination'. Is the angle between the horizontal and the plotted line between 24 and 30 steps per minute.

'Terminal Angle'. Is the angle between the horizontal and the plotted line between 30 and 36 steps per minute.

Caution: With older individuals and with anyone who is very unfit, the Progressive Pulse Ratio test should be administered before any 'all-out' tests like the Harvard Step test. If a subject reacts badly in the Progressive Pulse Ratio test, administration of the Harvard Step test is contraindicated.
Appendix I

Pulse Pressure Wave Measurements

Figure 1

Diagram of Pulse Pressure Wave
DESCRIPTION OF PULSE PRESSURE WAVE VARIABLES

1. **AREA UNDER THE CURVE (ABOFCIA)**

Two adjacent mitral valve closing points are connected for a single cycle. The area enclosed is traced with a polar planimeter. Each cycle is traced ten times, constituting one reading. The average area for three readings for three cycles is then determined.

2. **SYSTOLIC PULSE WAVE AMPLITUDE (AB)**

The measurement is made with vernier calipers in cms. and hundredths, nearly vertically and parallel to the blue time lines.

3. **DICROTIC NOTCH AMPLITUDE (ED)**

The measurement is made with vernier calipers in cms. and hundredths almost vertical and parallel to the blue time lines; from a baseline joining points A and C.

4. **FATIGUE RATIO (DE/AB)**

This measurement is the ratio of the amplitude of the dicrotic notch to the amplitude of the systole. The measurements are made as previously described.

5. **ANGLE OF OBLIQUITY (ABO)**

The angle is measured from the maximum systolic point of the graph. One line is drawn from point B to the centre of the hole in the graph. The other line is drawn almost tangentially to the upward systolic stroke line, through point A. Three sets, each made up of three cycles, is measured and the average angle is calculated. A protractor is used to measure the angles.

6. **PULSE RATE**

The regular rate of the heart is determined in beats per minute from the heartogram by counting the heart beats made on the graph in fifteen seconds then multiplying by four. The fractional part of a beat is estimated to the nearest tenth of a beat by inspection before multiplication.

7. **DIASTOLIC PULSE WAVE AMPLITUDE (FG)**

The part of the total heartograph in a single cycle which occurs after the semilunar valves close is represented by the diastolic pulse wave. It is measured by vernier calipers from the peak of the diastolic wave to the base line of the cycle, parallel to the blue lines.
8. **DIASTOLIC SURGE (FH)**

   The measurement of the diastolic surge is made with vernier calipers, parallel to the blue lines from a baseline drawn parallel to the cycle baseline (AC) to the maximum point of the diastolic amplitude.

9. **DIASTOLIC TIME (EC)**

   A horizontal measurement taken with vernier calipers from the Diastolic Surge to the end of the cycle. The measurement is taken in linear cms. and hundredths for convenience without conversion to seconds.

10. **SYSTOLIC TIME (AE)**

    The measurement is taken horizontally from the start of the systole to the close of the semilunar valves. The result is proportional to the time of systole and is taken in linear cms. and hundredths for convenience without conversion to seconds.

11. **REST TO WORK RATIO (AE/EC)**

    This measurement is the ratio of the systole contraction (from the start of the systolic stroke to the point of closing of the semilunar valves) to the overall time of diastole (from the point of closing of the semilunar valves to the start of the next systole). Measurements are described in nine and ten.

12. **DIASTOLIC BLOOD PRESSURE**

    This measurement is taken directly from the heartograph by reading the properly made line against the scale provided on the graph. The reading is in millimeters.

13. **SYSTOLIC BLOOD PRESSURE**

    This measurement is taken from the heartograph, as in twelve.

14. **PULSE PRESSURE**

    The difference between twelve and thirteen is determined by subtraction.
APPENDIX J

STATISTICAL TREATMENT

Study Design

Single Group, Test - Retest Experiment (N = 10)

\[ \bar{X}_I = \text{Pre-training Test Group Mean} \]
\[ \bar{X}_F = \text{Post-training Test Mean} \]

\[ \bar{X}_I (\text{Pre-training Test}) - \text{Experimental Factor} \]
\[ \bar{X}_F (\text{Endurance Exercise Program}) \]

- \[ \bar{X}_F = \text{Difference} \]

Procedure

1. Selection of subjects based upon attendance in previous year's fitness program.
2. Administration of cardiovascular tests to obtain pre-training scores.
3. Voluntary participation of subjects in the University of B.C. Physical Fitness Class held each day 12:30 to 1:30, Monday to Friday in the New Education Gymnasium. The program lasted seventeen weeks.
4. Administration of cardiovascular tests to obtain post-training scores.

Cardiovascular Fitness Tests

1. Schneider Test
   - Variables are: lying pulse rate, standing pulse rate, post-exercise pulse rate, time for pulse rate to return to standing value, difference between pulse rate lying to standing, and standing to post-exercise difference, lying and standing systolic blood pressure and the difference between systolic blood pressure lying and standing, index score.

2. Progressive Pulse Ratio
   - Variables are: recovery pulse counts for rates of 12, 18, 24, 30 and 36 steps per minute, average ratio and average angle.
3. Pulse Pressure Wave (Brachial Sphygmograph)
   - Variables are:
     A. Sitting
     - area under curve, systolic amplitude, dicrotic notch amplitude, fatigue ratio, diastolic amplitude, rest-to-work ratio, obliquity angle, systolic time, diastolic time, pulse rate, systolic blood pressure, diastolic blood pressure, and pulse pressure.
     B. Standing
     - area under curve, pulse rate, systolic amplitude, difference between sitting and standing systolic amplitude.
     C. Post Exercise
     - systolic amplitude.

In addition, the following measurements were made on all subjects:

1. Body Fat Measurements
   - Variables are: cheek fold, abdominal fold, hip fold, front thigh fold, gluteal fold, rear thigh fold, sum of all, and average.

2. Body Weight

General Statistical Outline

The significance of the mean difference between pre-training and post-training test scores was determined for all variables.

Test of significance of correlation co-efficient.

\[ H: \rho = 0 \]
\[ \bar{H}: \rho \neq 0 \]

\( \bar{H} = 0.05 \) level of confidence
\( \bar{H} < \bar{H} = 0.05 \) degrees of freedom \( N-2 = 8 \)

The value of \( \rho \) necessary to reject \( H = 0.558 \)

Formulae

1. Group Mean
   \[ \bar{X}_I = \frac{\Sigma X_I}{N} \]
   \[ X_I = \text{Raw Scores for Pre-Training Tests} \]
   \[ B. \bar{X}_F = \frac{\Sigma X_F}{N} \]
   \[ X_F = \text{Raw Scores for Post-Training Tests} \]
   \[ N = 10 \]
2. The Mean Difference Between Raw Scores

\[ \bar{X}_I - \bar{X}_F = d \]

\( d \) = Difference Between Pre-Training and Post-Training Raw Scores

\[ \bar{d} = \sum \frac{d}{N} \]

\( N = 10 \)

3. The Variance of the Difference

\[ S_d^2 = \frac{\sum d^2}{N} - \overline{d}^2 \]

\( d^2 \) = Squared Difference Between Pre-Training and Post-Training Raw Scores

\( \overline{d}^2 \) = Squared Mean Difference

\( N = 10 \)

4. An Estimate of the Variance of the Sampling Distribution of \( \bar{d} \)

\[ S_{\bar{d}}^2 = S_d^2 \frac{N}{N-1} \]

\( S_{\bar{d}}^2 \) = The Variance of the Difference

\( N-1 = 9 \)

5. t ratio

\[ t = \frac{\bar{d}}{\frac{S}{\sqrt{d}}} = \frac{\overline{d}}{\sqrt{S_d^2 \frac{1}{(N-1)}}} \]

\( d^2 \) = The estimate of the variance

\( N-1 = 9 \)
KEY TO APPENDICES K to R

K - L  Schneider Test Variables

1. Schneider Index Score
2. Difference Between Lying and Standing Systolic Blood Pressure
3. Standing Systolic Blood Pressure
4. Lying Systolic Blood Pressure
5. Pulse Rate Difference Standing - Post Exercise
6. Pulse Rate Difference Lying to Standing
7. Time for Pulse to Return to Standing Value
8. Post-Exercise Pulse Rate
9. Standing Pulse Rate
10. Lying Pulse Rate

M - N  Progressive Pulse Ratio Test. Variables

1. Total Recovery Pulse Counts - 12 Steps
2. Total Recovery Pulse Counts - 18 Steps
3. Total Recovery Pulse Counts - 24 Steps
4. Total Recovery Pulse Counts - 30 Steps
5. Total Recovery Pulse Counts - 36 Steps
6. Average Ratio
7. Average Angle

O - P  Body Fat Variables and Body Weight

1. Cheek Fold
2. Abdominal Fold
3. Hip Fold
4. Front Thigh Fold
5. Rear Thigh Fold
6. Gluteal Fold
7. Sum of All
8. Average of All
9. Body Weight
Q - R Pulse Pressure Wave

1. Sitting Area Under the Curve
2. Sitting Rest to Work Ratio
3. Sitting Systolic Time
4. Sitting Diastolic Time
5. Sitting Dicrotic Notch Amplitude
6. Sitting Fatigue Ratio
7. Sitting Diastolic Amplitude
8. Sitting Obliquity Angle
9. Sitting Pulse Rate
10. Sitting Systolic Blood Pressure
11. Sitting Diastolic Blood Pressure
12. Sitting Pulse Pressure
13. Sitting Systolic Amplitude
14. Standing Area Under the Curve
15. Standing Pulse Rate
16. Standing Systolic Amplitude
17. Difference Between Sitting and Standing Systolic Amplitude
18. Post-Exercise Systolic Amplitude
## APPENDIX K

**PRE-TRAINING SCHNEIDER TEST VARIABLES RAW SCORES**

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**Mean**

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### APPENDIX L

**POST-TRAINING SCHNEIDER TEST VARIABLES RAW SCORES**

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### APPENDIX M

**PRE-TRAINING PROGRESSIVE PULSE RATIO TEST VARIABLES RAW SCORES**

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**POST-TRAINING PROGRESSIVE PULSE RATIO TEST VARIABLES RAW SCORES**

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