A METABOLIC FUNCTIONAL CAPACITY TEST
FOR UPPER ELEMENTARY AGE BOYS

By

JOHN GILBERT BAYLESS

Bachelor of Science
Phillips University
Enid, Oklahoma
1957

Master of Education
Phillips University
Enid, Oklahoma
1961

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Thesis Approved:

Aix B. Harrison
Thesis Adviser

Albin P. Warner

Valerie Colvin

H E Sorenson

J H Boggs
Dean of the Graduate School

PREFACE

A matter of current national concern is physical fitness. Many aspects of this problem have been investigated in the past, but little has been done in the area of endurance. This study has had as its purpose the development of a metabolic functional capacity test for upper elementary age boys.

I entered college teaching with a desire to advance the knowledge now in the field of health, physical education, and recreation. There are several ways of doing this and I believe that one of these ways is to develop tests and measurements for evaluation in this field. I am confident that the test of endurance presented in this study will give the physical educator in the field a tool that he might use with confidence.

I thank my advisory committee, Prof. Valerie Colvin, Dr. Julia McHale, Dean Helmer Sorenson, Dr. Albin Warner and Dr. Aix Harrison for their very valuable guidance in the development of this study. Indebtedness is also acknowledged to those whose help made this study possible, especially to those boys who participated in the study.

Special thanks go to my wife, Betty Bayless, for her unfailing encouragement and understanding throughout the undertaking of this study.

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CHAPTER I

INTRODUCTION

Background of the Study

Physical fitness is a term which has been rather difficult to define objectively. About the simplest definition is: the capacity of an individual to perform a given task. Dr. Peter Karpovich, M.D. of Springfield College, Springfield, Massachusetts, defines physical fitness as "a fitness to perform some specified task requiring muscular effort."[1] Dr. Bruno Balke of the University of Wisconsin states that "the best test of physical fitness would be men's ability to survive under extra-ordinary biological demands."[2] There are many facets of physical fitness. Some of these are strength, flexibility, cardiovascular fitness, neuro-muscular coordination and endurance. This study was concerned with endurance as a phase of fitness. In this study physical fitness was assessed by determining the subject's potential capacity for high energy demands. Total work capacity is made up of two phases, the aerobic and anaerobic phase. The first phase, the aerobic phase, occurs when an adequate supply

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[1]Peter V. Karpovich, Physiology of Muscular Activity (Philadelphia: 4th ed.: W. B. Saunders Co., 1953), p. 260.

[2]B. Balke, "The Effect of Physical Exercise on the Metabolic Potential, a Crucial Measure of Physical Fitness," Exercise and Fitness, ed. The Athletic Institute (Illinois, 1960), p. 73.

of oxygen is available to an individual and results in the complete utilization of carbohydrates to produce carbon dioxide and heat. During muscular exercise, the blood vessels leading to the muscle dilate and blood flow is increased so that the available oxygen supply is increased. The magnitude of this increase is indicated by the fact that the metabolic rate of a muscle during exercise might be increased to 100 times its rate at rest. When muscular exertion is extremely high, aerobic resynthesis of energy stores in the body cannot keep pace with their utilization.[3] At this moment the individual's metabolism reaches what is called the crest load. This is described as the point where the largest work load for which the oxygen intake of the body is adequate to meet the oxygen requirement.

The second phase of work capacity is anaerobic. This phase occurs when there is an inadequate supply of oxygen during work. The oxygen requirements exceed the aerobic capacity and are met by the body's ability to incur a certain amount of oxygen debt. Oxygen debt is a deficit incurred during anaerobic work, and the lactic acid and other by-products of work serve as promissory notes assuring prompt payment.

Authorities have agreed that endurance is the ability to continue work. This is limited by two factors; first, the willingness to work on in spite of the discomfort and pain of fatigue, and secondly the capacity of the homeostatic mechanism to make rapid and extensive adjustments within the functioning organism.

A definition of an individual possessing endurance would be a person who has lowered the sensitivity thresholds, while homeostatic adjustments

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[3]William F. Ganong, Medical Physiology (Los Angeles, California, 1963), p. 36.

are taking place as the body becomes experienced to increased metabolic demands. The blood circulates more freely because of a more effective adjustment by the vasomotor system which goes into action even before the activity is commenced and shifts the blood to the working muscles in just the proper volume as the work is continued. At this time pulmonary ventilation is keeping pace with the requirements for gaseous exchange rather than over-responding to the excitement of exercise, which sometimes produces giddiness due to chemical imbalance will no longer strive for air with a continually expanded chest, but permits a full excursion of his thoraco-diaphragmatic bellows to provide an efficient ventilation of his lungs. The subject's perspiration is almost entirely free from eye-stinging salt, since the sweat glands are capable of excreting the water needed for cooling while conserving the salts needed to maintain the delicate fluid balance of the body.

There are two basic types of test used in the measurement of endurance. These are laboratory tests and field tests. Balke has found that procedures for determining human working capacity in the laboratory take advantage of such equipment as treadmills, bicycle ergometers or stepping devices for providing desirable and reproducible levels of work intensity. The test that Dr. Balke and his associates have used in the laboratory has been primarily with the treadmill. The laboratory conditions allow for a continuous monitoring of the circulatory and respiratory responses to exercise which is essential for the recognition of an individual's capacity for coordinating a complexity of organic functions. Most researchers testing large numbers of students have found that treadmills and bicycle ergometers are quite expensive.

Since the use of this equipment would not be practical for testing large numbers there is a need for field tests. Balke states "that without 'on-the-spot' measurements, most tests involving physical exertion are too dependent on the individual's motivation and tolerance for pain and discomfort. Without physiological measurements during a 'fitness' test an investigator can rarely ascertain if the subject is performing within or beyond his physiological limitations. A field test of physical competence should engage a familiar type of physical exercise involving large muscle groups and eliciting general functional responses within and up to the limits of capacity. The test accomplishments should be simply measureable in commonly understandable terms and readily convertible into data of physiological significance."[4] The type of exercise which comes very close to fulfilling most of these requirements is the work of walking and running. Balke has shown in Figure 1 (page 6) his attempt to illustrate the role of the oxygen debt capacity during the performance of exercises requiring near all-out efforts compared to time intervals from 1 to 15 minutes. It can readily be seen that a very short effort, e.g. running 100 yards in 10 seconds, is accomplished almost entirely anaerobically. In a four-minute run the oxygen debt capacity covers about twenty per cent of the work. In work periods exceeding 12 to 15 minutes, the anaerobic phase becomes less and less important for the accomplishment of the total work, accounting for not more than approximately five per cent of the totally required amounts of oxygen. On this basis, Balke

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[4]B. Balke, "A Simple Field Test for the Assessment of Physical Fitness," Report to the Federal Aviation Agency, Civil Aeromedical Research Institute, Oklahoma City, Oklahoma, p. 1-2.

has recommended the 15 minute run as a field test of endurance.[5]

In 1942, Johnson, Brouha and Darling introduced the "Step Test" as a method of assessing one's physical fitness for strenuous exercise. The test required a subject to step on to a 20-inch bench at the rate of 30 steps (4-count cycles) per minute as long as he is able, or if still stepping at the end of five minutes the exercise is terminated. The recovery pulse is then counted from 1-1½, 2-2½, and 3-3½ minutes after the cessation of exercise. The five minute step test according to Montoye cannot be a test for work performance prediction. Montoye concludes "despite the fact that work performance cannot be predicted from Step Tests scores there is an appreciable amount of evidence that the Index does reflect the relative state of fitness of the cardiovascular system."[6] It appears from the results of Montoye's study that the Fitness Index is not very closely related to one's ability to carry on strenuous work.

At present the most widely used field test for endurance is the 600 yard walk-run test presented by the American Association of Health, Physical Education and Recreation. The 600 yard run can be completed by most anyone in two to three minutes. It can be seen from Figure 1 that this would mean that 20-40% of the work was being done anaerobically. Because of the strain on the subjects and complaints from parents on the distance of the test the 600 yard walk-run has not been generally accepted. At present there are no generally accepted field tests of endurance that have been validated.

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[5]Ibid.

[6]Henry J. Montoye, "The Harvard Step Test," Revue Canadienne de Biologie, 4 (1952), pp. 491-499.

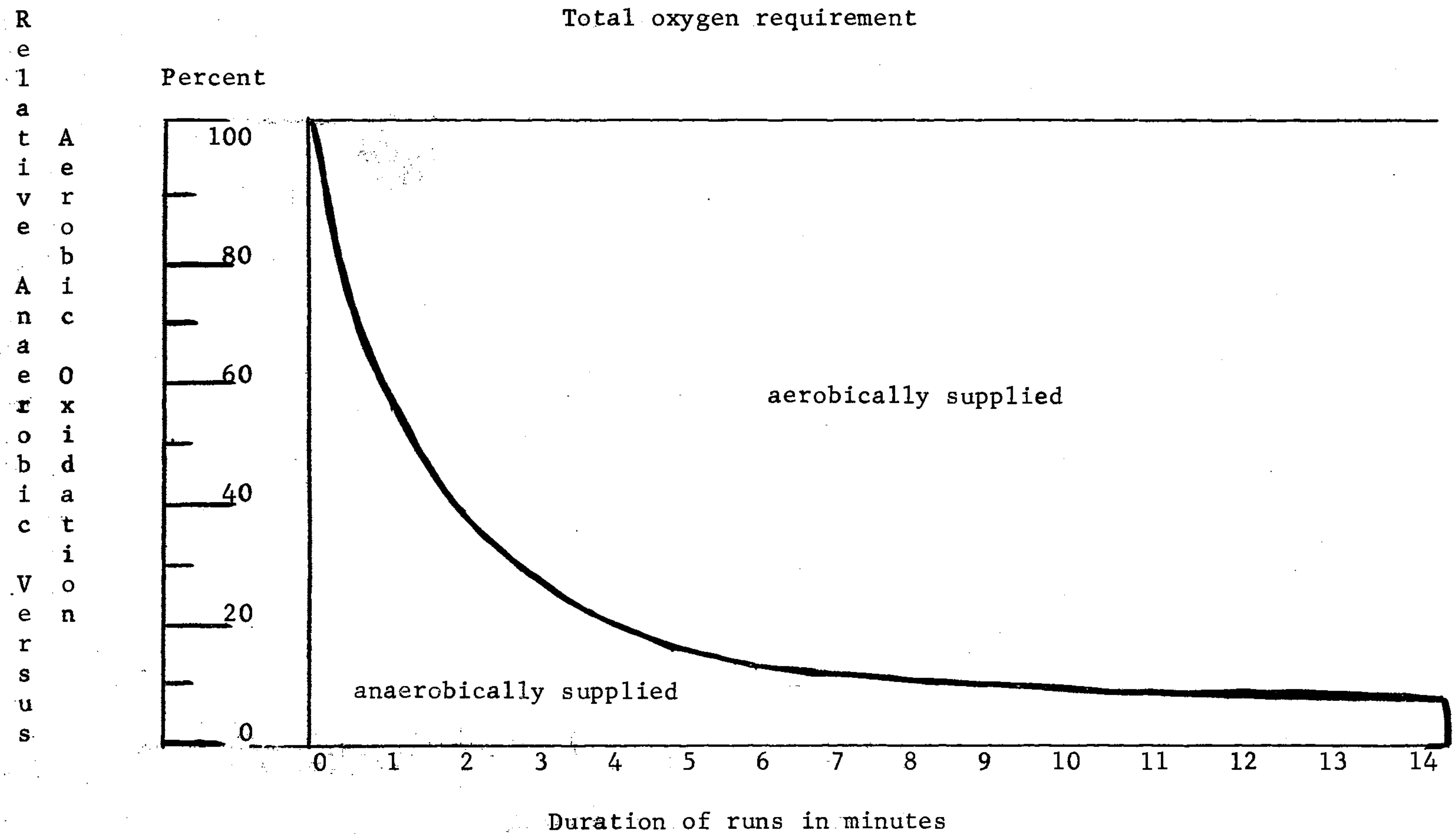

Figure 1. Relative Percent of Aerobic and Anaerobic Work During 15 Minute Run. (Balke)

The practical problem involved in this study was that of establishing a test that could be used by physical educators in the field to test endurance. When one is attempting to assess the endurance of individuals as part of physical fitness it is necessary to have an objective method of testing which will readily indicate the magnitude of changes in physical condition derived from physical conditioning, extended periods of complete inactivity, and physical fatigue. In this study it was hoped that a procedure could be found that would serve the purpose of determining a person's crest load capacity for functional demands of aerobic work, commonly referred to in this study as endurance.

There have been previous studies conducted with adults and high school age students that have established foundations for this study. Balke has worked on testing endurance in adult males and females, as well as high school boys. Balke's test for adult males utilized a treadmill to increase the work load. This testing procedure is generally accepted among physiologists and physical educators. The criteria for this test is the length of time the person can walk on a treadmill with a gradually increased work load until anaerobic work is reached.[7]

Balke has also experimented with a portable stepping device using both healthy and cardiac male subjects. He started these subjects stepping at the floor level, raising the step interval 2 cm. per minute. The results of this test indicated a high correlation with those of the more

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[7]Bruno Balke, "The Effect of Physical Exercise on the Metabolic Potential," Exercise and Fitness, ed. The Athletic Institute (Illinois, 1960), pp. 73-81.

elaborate treadmill tests.[8]

Balke, Clarke and Phillips in separate studies have theorized that children respond differently in pulse rate and blood pressure patterns than adults to this type of test.[9] At the present time there are no established tables of norms for children using this proposed administrative technique for testing of endurance. This is the reason for a separate validation and norming procedure for children.

Purpose of Study

The purpose of this study was to establish a metabolic functional capacity test as a measure of endurance for upper elementary boys ages eight through twelve. The procedure was a step test utilizing a motorized stepping device. It was first necessary to establish the starting height of the step, progression of work load through speed of elevation, how often the step was to be raised, and what pulse rate do the boys attain before reaching the cut-off point between aerobic and anaerobic work.

Another problem associated with this study was to find the point during exercise where the subject's systolic blood pressure dropped significantly representing the cut-off point between aerobic and anaerobic work load.

These work loads refer to those levels of work where in the step test the step was elevated every minute, thus increasing the energy

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[8]Letter from Dr. Fran Nagle, Biodynamic Branch, FAA Center, Oklahoma City, Oklahoma to Dr. A. Harrison, Oklahoma State University, Stillwater, Oklahoma, October 1964.

[9]B. Balke, Exercise and Fitness, p. 75.

demands gradually. These demands are met by proper adjustments of the cardio-respiratory systems. The increase in heart rate and pulse pressure change indicates the enlargement of the cardiac output which is of primary importance for adequate oxygen and energy supply. The progressive demands on the respiratory system, handling the metabolic gas exchange, are expressed by the increase of pulmonary ventilation.

Balke and others have found that in adults the functional limitations become apparent when the heart rate reaches about 180 beats per minute.[10] At this critical frequency, the time for sufficient ventricle filling with blood between contractions becomes too short, and as a consequence of reduced blood volume, the pulse pressure falls off. At this point man also encounters his maximal capacity for breathing. This is the point where the aerobic process leaves off and the anaerobic process takes over. These criteria, indicating the attainment of maximum aerobic capacity, are observed at low work intensities in subjects with low functional capacities and at higher work intensities in subjects, who, by training, have become functionally adapted to greater demands. The test was terminated before the subject went into anaerobic oxygen debt at a heart rate of around 180 beats per minute and after a drop in systolic blood pressure was noted.

The test used in this study was one which may fill one of the serious weaknesses in our current fitness testing program by providing an economical and easily administered test which would give information about the child's functional capacity and cardio-respiratory reactions to moderate

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[10] Stacy Hoover Mathews, Physiology of Muscular Activity and Exercise (The Ronald Press Co., New York, 1964), p. 363.

exercise. The stepping device that was used in this study can be built for around $100.00. After validity and norms have been established for the test, any physical education teacher could administer the test with some training in taking pulse rates and operating the stepper.

It is hoped that both the equipment and the knowledge gained from this study will be used in an additional study of work capacity of children. Some of the sub-problems of this study were:

1. the measuring of energy cost during the test
2. establishing norms
3. measuring net oxygen debts incurred during this test
4. determining the mean pulse rate that a child attains before he reaches the cut-off point between aerobic and anaerobic work.

Limitations

The sample for this study was not a random sample because of the time factor and lack of controlled sampling procedures during summer months. The number of subjects in the test was relatively small for establishing norms.

Upon arriving at the laboratory the boys were somewhat apprehensive as to what was going to happen. With all of the instruments and testing devices in the room the subjects seemed to build high anxieties. Several of the boys became so excited they hyperventilated during the early part of the test procedure. This was a factor that could not be controlled.

The boys' activity prior to coming to the laboratory was also another factor that could not be controlled.

CHAPTER II

REVIEW OF LITERATURE

In making this study of metabolic functional capacity of grade school boys it was necessary to cover the literature as thoroughly as possible to find what information had been uncovered before this study. Several individuals have made studies directly or indirectly concerned with the topic at hand.

Some of the first work capacity studies were done by measuring cardiac output. The earliest methods of studying cardiac output involved the problem of the blending of gases in the lungs. The factors determining this blending have been investigated by many workers. A systematic study has been reported by Lundsgaard and Schierbeck (1923), where references to the earlier work may be found. They concluded that results obtained with hydrogen could be extended to other gases (oxygen, nitrous oxide, and carbon monoxide). Three main factors presented themselves to these investigators for study; (1) the amount of air in the lungs after expiration, (2) the depth of rebreathing, and (3) the number of rebreathings. By rebreathing from a rubber bag, containing 2 to 2.5 liters of a hydrogen-air mixture, and starting from the residual air of the subject, they found that three respirations were sufficient for attaining mixture in the two subjects studied. Regarding the rate of respiration which in most of these experiments was between 10 and 16 per minute, they state, "a few experiments were performed in order to determine quantitatively the influence of the rate. We did not arrive at definite results. Our impression was that rate may be varied considerably without any appreciable influence on the results."[1]

In 1942, Johnson, Brouha and Darling introduced the "Step Test" as a method of assessing one's physical fitness for strenuous exercise. This initial test was explained in Chapter I.[2] Although the test was originally developed for appraising the fitness of healthy men, modifications have rendered the test applicable to boys, young women, girls, and older men and patients. One modification for the girls was; those who became fatigued may have to be stopped before the five-minutes period was completed. This test was devised as suitable for estimating the dynamic physical fitness of high school girls. The test is based upon the principle that the more fit an individual, the more rapidly will the heart rate return to normal after exercise. The equipment consisted of a platform 16 inches high and a stop watch.

Since the publication of the initial research in Revue Canadienne de Biologie,[3] the Fitness Index has been subjected to numerous critical evaluations. Despite severe criticism in some quarters the Index has gained rather wide-spread popularity. The Step Test is purported to measure "the functional status of the body and its ability to do strenuous work.

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[1]C. Lundsgaard and K. Schierbeck, "Respiratory Breathing Rate," Journal of Physiology, LXIV (1923), p. 210.

[2]R. E. Johnson, L. Brouha, and R. C. Darling, "A Test of Physical Fitness of Strenuous Exertion," Revue Canadienne de Biologie, 1 (1942), pp. 491-503.

[3]D. Mathews, Physiology of Muscular Activity and Exercise (New York, 1964), p. 373.

To measure indirectly, or in other words to predict, one's capacity for doing muscular work would indeed be valuable.[4] The validation against a work criterion of similar simple tests of fitness which have appeared in the past have, for the most part, failed. It was the purpose of Montoye's study to determine the relationship between the Fitness Index (Step Test Scores) and several criteria of work performance.[5] Similar attempts have been made by others and their results are discussed by Montoye. However, the number of experimental subjects in some instances was small. Furthermore, it seemed important that the subjects be conditioned to strenuous work before administering the Step Test and tests of work performance. Montoye found the relationship between the Fitness Index and work performance in fifty college men who had participated in a strenuous conditioning program for three months. Criteria of work performance consisted of maximum number of sit-ups, time on a half-mile run, and duration of maximal performance on frictional bicycle ergometer peddled at the rate of 20 miles per hour against four pounds resistance. The computed coefficients of correlation between the step test scores and the criteria were 0.286 and 0.091 respectively. These results corroborate the work of others indicating that there apparently was some slight relationship between the Fitness Index and height, weight or surface area. Although age in Montoye's study was statistically significant it was considered relatively unimportant. Montoye's conclusion was that the low correlation

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[4]J. R. Gallagher and L. Brouha, "A Simple Method of Testing the Physical Fitness of Boys," Research Quarterly, 14 (1943), pp. 23-30.

[5]Henry J. Montoye, "The Harvard Step Test," Revue Canadienne de Biologie, 4 (1952), pp. 491-499.

between the Fitness Index and measures of stature, weight and surface area was not surprising in view of the results of Bookwalter[6] and Seltzer.[7]

Bookwalter correlated results of the Army Physical Fitness test and the Harvard Step test only to find no significant relationship. He also found that Step Test scores are apparently independent, for all practical purposes, of structural measurements.[8]

An influential researcher that has contributed his knowledge to the type of test done in this study was Dr. Bruno Balke. He has stated in his studies that "Procedures for determining human working capacity in the laboratory take advantage of such equipment as treadmills, bicycle ergometers, or stepping devices for providing desirable and reproducable levels of work intensity."[9] Balke reports test results in terms of the duration of exercise required to produce a heart rate of 180/min. The test consists of walking at a constant speed on a treadmill, the slope of which is increased each minute. The heart rate is measured each minute. The test requires a treadmill, a stop watch, and an electrocardiograph heart rate.[10]

The type of exercise which comes very close to fulfilling most of

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[6]K. W. Bookwalter, "A Study of the Brouha Step Test," Physical Educator, 5 (1948), p. 55.

[7]C. C. Seltzer, "Anthropometric Characteristics and Physical Fitness," Research Quarterly, 17 (1946), pp. 10-20.

[8]Bookwalter, p. 55.

[9]B. Balke and R. W. Ware, "An Experimental Study of 'Physical Fitness' of Air Force Personnel," U.S. Armed Forces Medical Journal, 10 (1959), p. 675.

[10]B. Balke, Journal of Applied Physiology, 7 (1954), 231.

these requirements Balke mentions is the work of walking and running. According to Henry's compilation of data on the oxygen requirements for these exercises, level walking at a fast pace produces metabolic rates up to eight times the resting value while in relatively slow running the energy expenditure may exceed the resting rate as much as 10 times or more. This explains why most "normal" people usually become quickly exhausted when "in a hurry."[11] About 70 to 80 per cent of the adult male population attain cardiorespiratory limitation at energy expenditures of 10-11 mets (Mets: multiples of the basal metabolic rate).[12] In another of Balke's studies a simple but very efficient form of exercise, namely hiking up-hill on a motor driven treadmill was used as an appropriate stress factor. Stress was gradually increased by elevating the slope of the treadmill one per cent per minute. Thus during walking at a constant speed of 3.4 m.p.h. the energy demands were gradually increased. These demands were met by proper adjustments of the cardio-respiratory systems: the increase in heart rate and in pulse pressure indicated the enlargement of the cardiac output which was of primary importance for adequate oxygen and energy supply.[13]

Balke experimented with another test of endurance. He had a group of 34 high school boys with an average maximal oxygen intake of 43.6 ml/kg/min in the treadmill test run 15 minutes on an oval track. They

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[11]F. M. Henry, "The Oxygen Requirement of Walking and Running," Research Quarterly, 24 (1953), p. 169.

[12]B. Balke, Exercise and Fitness, pp. 73-81.

[13]Ibid, p. 75.

were to cover the greatest possible distance during that time. The boys averaged a velocity which required an oxygen intake of 44.4 ml/kg/min. Most boys stayed well within the acceptable range of ± 10% deviation from the perfect correlation between maximum oxygen intake and distance covered. A few boys performed better in the running test than was predictable from the objective treadmill data. Based on Balke's findings a field test for the assessment of physical fitness was established which employs a 15-minute run--around or along known distances--at best individual efforts. From the accurate distances and time measurements of the average velocity in meters per minute was determined and converted into the physiologically meaningful value of equivalent oxygen requirement. In a "best effort" this value represents very closely the aerobic work capacity and permits a rather objective rating of physical fitness.[14] Dr. Nagle and Dr. Balke have also experimented with a motorized stepper using as subjects healthy and cardiac males. These researchers started the stepper at 2 cm. and raised it 2 cm. each minute. Only three of twenty-six subjects continued stepping to a height of 40 cm. and going twenty minutes in duration. These same men started at the end of one minute of exercise with a mean VO_2/ml/kg of 10.0 and three raised this to a mean VO_2/ml/kg of 41.3 at the end of the twentieth minute. Balke and Nagle gave the following scale as their classification index for the step test.

[14] B. Balke, "A Simple Field Test for the Assessment of Physical Fitness," Report from Federal Aviation Agency, Oklahoma City, pp. 1-11.

TABLE I

WORK CAPACITY STANDARDS

VO_2/ml/kg	Classification
25-30	Very Poor
30-35	Poor
35-40	Fair
40-45	Good
45-50	Excellent
50-55	Superior

There was a high correlation between Balke's treadmill and 15 minute run tests and the step test.[15]

According to practical experience in the field, a state of complete exhaustion was to be expected after about two hours of slightly submaximal work on the treadmill. During such work, the organism is running out of readily available energy stores which are mainly composed of the glycogen deposits in muscles and liver.[16]

Incompetence is indicated near this rate by: (a) an excessive volume of ventilation; (b) a respiratory exchange ratio of unity; (c) an acute decrease in the ratio of oxygen consumed to the work done; (d) a tendency for the oxygen consumption to level off, indicating increased anaerobic

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[15]Letter from Dr. Fran Nagle, Biodynamic Branch, Federal Aviation Agency, Oklahoma City, Oklahoma, to Dr. A. Harrison, Oklahoma State University, October 1964.

[16]R. Hedman, "The Available Glycogen in Man and the Connection between Rate of Oxygen Intake and Carbohydrate Usage," Acts Physiology Scandanavia, 40 (1957), p. 305.

work. This is demonstrable if the exercise is graded to allow for physiological adaptation at the various work levels.[17]

For some of the calculations in this study reference was made to Physiological Measurements of Metabolic Functions in Man by Consolazio, Johnson and Pecora. On the basis of their experience they have established procedures for other researchers to use in metabolic calculations.[18]

Another field test that is being used at present is the 600-yard run-walk. This test is a screening measurement in the suggested elements of a school-centered program for Youth Physical Fitness. The students start running on an oval track with the signal to "Go!". They run the full distance (walking only if necessary). Walking is permitted, but the object is to cover the distance in the shortest possible time. The record in time is the basis for scoring the 600 yard run-walk.[19]

In summary, the procedures that have been used in the past to measure endurance have been questioned. Most of the earlier test that have been done, have been of the anaerobic phase of exercise. Since Balke's studies have been made there are a few researchers that are carrying these studies on into different areas of testing. In Balke's testing procedure there was involved much elaborate and expensive equipment. It is hoped through the efforts of this study that expense can be kept at a minimum and a valid and reliable test of metabolic functions can be found.

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[17]Ibid, p. 306.

[18]Consolazio, Johnson and Pecora, Physiological Measurements of Metabolic Functions in Man (St. Louis, 1964).

[19]President's Council on Youth Fitness, Youth Physical Fitness, Suggested Elements of a School-Centered Program (Washington 25, D.C.: Superintendent of Documents, U.S. Government Printing Office, 1961), p. 54.

CHAPTER III

METHOD AND PROCEDURE

Establishment of Testing Procedure

The first step in the establishment of this test was to develop a procedure and have a trial run. It was decided to start with a stepping height of four inches and increase the height of the step interval one inch every minute of exercise. This choice was influenced by Dr. Harrison's study using adult men starting at a height of eight inches[1] and Dr. Balke's and Dr. Nagle's studies starting at floor level.[2] The decision was made to use four inches as the starting point for this test; this point being a mid-point between the above two levels.

One subject was asked to come to the physical fitness laboratory for a trial run of the test wearing tennis shoes and sports apparel. Subject K. E., age twelve was chosen and tested because of his age, good health and availability. K. E. reached his crest-load at the end of the seventh minute. This was derived from observation of his metabolic calculations. His systolic blood pressure fell from 128 mm. Hg. to 122 mm. Hg. on the seventh minute of exercise with the step at a height of ten inches. K. E.'s oxygen content of expired air was 16.05 per cent at the end of

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[1]A. Harrison, "Swim for Fitness," Physical Educator, 22 (October, 1965), p. 129.

[2]B. Balke and F. Nagle, p. 18.

the seventh minute and fell to 15.85 per cent on the next minute. From the results of these calculations the procedure was chosen.

Selection of Subjects

After the procedures had been checked out on the one subject the researcher chose twenty-nine more subjects from a summer swimming program that he was teaching. The only prerequisite being that the subjects needed to be between the ages of eight and twelve. All of the boys had physical examinations before entering the swimming program, although this was not absolutely necessary since the test was sub-maximal and would not prove injurious to the subjects. The time schedule was set and the subjects came to the laboratory in groups of three or less. After all of the subjects had been tested, five were asked to return for a retest to check the reliability of the test.

Administration of the Test

After arriving at the laboratory the subjects height and weight was taken and recorded, also the following measurements; grip strength, push-pull strength, skinfold fat and vital capacity. These measurements, however, were not used in this study. They were given to acquaint the subject with the laboratory and testing procedures. Following these tests the subject was asked to sit in a chair facing the stepping device. The cuff of the sphygmomanometer was attached to the subject's upper arm. The stethoscope bell was attached to the subject by means of a wrap to the cubital area where the brachial, radial and ulnar arteries intersect. A long section of rubber tubing was attached to the hearing device on the stethoscope. This additional length in tubing permitted the subject to have freedom of movement and also allowed the researcher to be free for other testing procedures.

After a five minute rest in the chair the subject's resting pulse rate and blood pressure were taken. A three minute resting metabolism was then taken. A one way valve and mouthpiece was attached to a modified football helmet by means of the face protector attachment on the helmet, thus freeing the subject from having to support the weight of the valve in his mouth. A nose clip was attached to the subjects nose so as not to allow exhaled air to escape from his nasal passages. The subject's expired air was accumulated in a Collins 120 liter clinical spirometer. The resting metabolism was calculated from analysis of gas samples taken from the spirometer. A volume of the expired air was taken from a kymograph connected to the spirometer.

Following the resting recordings the testing of exercise started. The subject was introduced to the stepping procedure. He was told to step up and down on the stepper to the rhythm of the metronome (120 steps/min.) keeping his eyes on the stepper, thus lowering the possibility of falling into the equipment. The subject was told of the pressure that would be on his arm when the tester was taking his blood pressure. At this time the subject was asked to try the stepping procedure and the importance of keeping the rate of 120 steps per minute was re-emphasized. The test was administered on a portable, motorized stepping device which was designed and built for this purpose by the Federal Aviation Agency, Oklahoma City, Oklahoma. The stepper can be raised from ground level to a maximum height of 20 inches by simply switching on a toggle switch.

The device provides a stepping platform which could be varied to any height from ground level to twenty inches while work was being performed. The height of the step at the beginning was four inches and each minute the height of the platform was raised one inch to produce corresponding increases in work load. In this test procedure the step was raised during the last fifteen seconds of every minute during the test. The first forty-five seconds of each minute was used for sampling procedures.

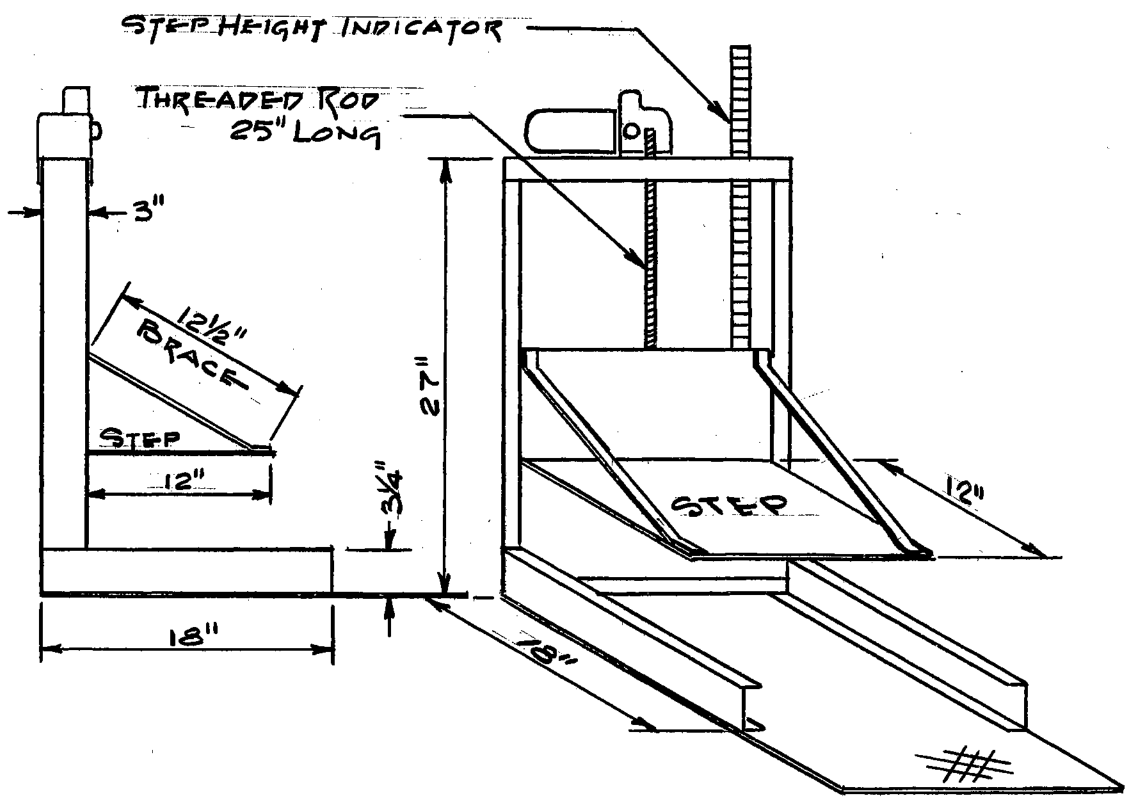

Figure 2. Schematic Drawing of Motorized Stepper

It was necessary to have a minimum of two people present to administer the laboratory test. One individual took the heart rates and blood pressure readings with a stethoscope, recording these every minute. The other tester moved the stepper and took expired air samples from the spirometer, which included removing and adding the meterological balloons with each sample.

During the Metabolic Functional Capacity Step Test the same measurements were taken as those taken during rest. The systolic and diastolic blood pressure readings and heart rate were taken every minute of exercise. Sample volumes of expired air were taken in the spirometer for fifteen seconds of every minute. The sampling procedure was achieved immediately following the raising of the step or during the first fifteen seconds of every minute. The expired air samples for analysis were taken from the spirometer during the third minute, fifth minute, seventh minute and every minute thereafter until it was evident that the subject had reached his crest load. This point being that which determines cessation of aerobic and beginning of anaerobic work. This was projected to be where the systolic blood pressure rises during sub-maximal work and tends to drop upon reaching the crest load. It has been shown that the crest-load was reached in adults when the heart rate is 180 beats per minute.

The test was terminated when anaerobic work began in the subject as indicated by pulse rate and systolic blood pressure. The time that it took each subject to reach this level was an indication of his metabolic functional capacity. Most subjects were encouraged to go one minute past this point to provide potential validating data from various metabolism measurements. It was estimated, from previous tests on adults, that an average subject would take from seven to twelve minutes to complete the test. The complete testing procedure took ten minutes plus the amount of time the subject stepped.

At the conclusion of the test the subject sat in a chair with all testing apparatus intact and recovery measurements were taken. These measurements were blood pressure, heart rate and fifteen second expired air samples for three minutes following exercise. The expected results of these measurements were that the subjects heart rate, blood pressure and rate of breathing would return to resting levels or close to these. The amount of time it took this return to happen is an indication of the condition of the individual. It was also necessary to have the recovery measurements available for calculation of oxygen debts.

Analysis of Expired Air

The fifteen second expired air samples were taken from the spirometer during resting, exercise and recovery in rubber meterological balloons and retained until after the test was completed. These samples were then analyzed by the gas chromatography method for oxygen, carbon dioxide and nitrogen content. The recorder and gas chromatograph were warmed up thirty minutes to an hour before analysis was to be made. This was to assure that the balancing of the machine was valid. The helium gas was turned on to assure proper flow during time of testing.

Two samples of two known calibration gases and their quantities of oxygen and carbon dioxide were recorded to assure validity of the calculations. A calibration graph based on these recordings was constructed for each days work.

The samples of expired air were fed into a V-25 Fisher Gas Partitioner through the gas sampling valve on the front of the partitioner directly from the meterological balloons. A syringe and needle can be used to inject samples into a small rubber port hole on the top of the instrument, but the use of the gas sampling valve increases reproductivity. Helium gas was used as a carrier gas for the chromatograph. The total analysis procedure including nitrogen takes about three minutes per sample depending on the selected flow rate of helium. The chromatograph partitions the amount of oxygen, carbon dioxide and nitrogen in each sample. The amounts were recorded on a Sargent Recorder connected to the partitioner. A correction factor for argon was used in calculating the oxygen percentages as suggested by Hamilton. The correction factor was (.8) and merely involved a simple subtraction of this factor from the raw oxygen percentage.[3]

At least two samples of the resting gas was checked to assure reliability. In other readings where there seemed a lack of consistency, a second sample was tested. With previous experience on the chromatograph it was found not to be necessary to check all samples twice unless there was some inconsistency.

Each sample was also measured in the spirometer for volume by use of the kymograph attached to the spirometer. A temperature and barometric pressure reading was taken each day. These were used to apply standardized corrections on all gas volume measures. With these calculations

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[3]L. H. Hamilton and R. C. Kory, "Application of Gas Chromatography to Respiratory Gas Analysis," Journal of Applied Physiology, 15 (1960), pp. 5, 829-837.

(volume, O_2 and CO_2) the respiratory quotient, and true oxygen, energy cost and oxygen debt figures were derived from metabolic tables. These procedures for metabolic calculations were taken from Metabolic Methods by Consolazio, Johnson and Marek.[4]

The testing of the subjects, gas analysis and basic calculations before grouping of figures consumed approximately three hours per subject.

Grouping and Analysis of Data

Upon completion of all tests and metabolic calculations, the data was divided into two groups, according to ages, 8 to 10 and 11 to 12. Group data was compared for differences in pulse rate, blood pressure and metabolic variables due to age. After comparing data from these groups and finding almost no differences it was decided to use the data as coming from one homogeneous group. Graphs and charts were constructed showing the data obtained including energy cost ratio, blood pressures, pulse rates, oxygen and carbon dioxide content of expired air and respiratory quotients.

A suggested test procedure for others to follow was outlined with tentative norms based on minutes of work accomplished before cut-off pulse rate was reached. The data, as shown by tables and graphs in the summary were analyzed for supporting evidence for validity of cut-off points based on this data.

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[4]Consolazio, Johnson and Marek, _Metabolic Methods_ (St. Louis, 1951).

CHAPTER IV

RESULTS

This study has attempted to establish a test that could be used by physical educators in the field to test endurance. Originally it was decided the results of the test would be divided into two age groups.

The data in the following table reflects the closeness of the metabolic calculations for these two groups. Group I had those subjects ages eight, nine, and ten. Group II had those subjects ages eleven, twelve and thirteen.

TABLE II

MEAN CUT-OFF POINTS OF TWO GROUPS TESTED

Data Taken	Group I	Group II
Systolic Blood Pressure	116 mm.Hg	122 mm.Hg
Diastolic Blood Pressure	68 mm.Hg	67 mm.Hg
Heart Rate per 15 sec.	45	46
Ventilation Rate per minute	45	43
Oxygen Percentage (Expired Air)	18.09%	17.23%
Carbon Dioxide (Expired Air)	3.21%	3.35%

On the basis of the above evidence being so close it was decided to treat all subjects as one group.

One of the sub-problems of this study was to find how long the subjects would exercise before reaching their crest-load. The data in Figure 3 shows that the largest number of students stepped for eight minutes with the next highest number at seven and nine minutes. These scores agree highly with the metabolic calculations shown in Figures 4, 5 and 6.

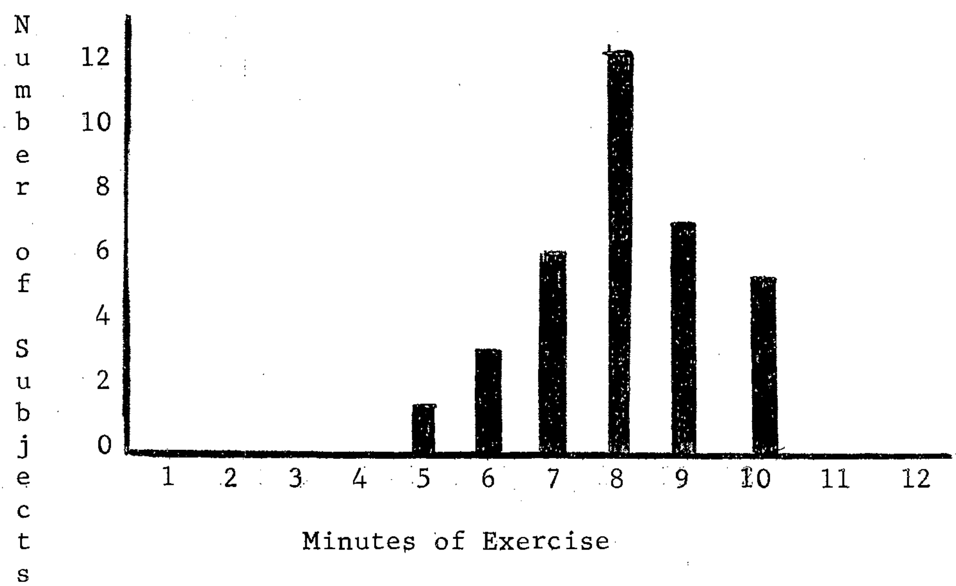

Figure 3. Total Number of Subjects Crest-Loads for for Each Minute of Test

To assess the significance of the results shown in Figure 3 it was necessary to compare these figures with other variables of the test. These crest-loads by the minute were used in establishing test norms for field-test use.

The data that supported the crest-load being close to the eighth minute of exercise is that of the calculations in Tables III, IV, and V.

These tables and accompanying graphs indicate a crest-load between aerobic and anaerobic work.

Table III gives the test data for mean systolic blood pressure and ventilation rate. Both of these variables had a breaking point of seven minutes.

TABLE III

METABOLIC CALCULATIONS HAVING A BREAKING POINT OF SEVEN MINUTES

Minutes of Exercise	Number of Subjects	Systolic Blood Pressures mm.Hg	Number of Subjects	Mean Ventilation Rates L/min
0-1	30	106.866	8	33.5
1-2	30	111.133	11	32.3
2-3	30	114.733	25	33.28
3-4	30	118.466	10	33.4
4-5	30	121.133	25	37.16
5-6	29	121.758	13	36.30
6-7	29	123.448	26	40.11
7-8	27	120.258	19	42.84
8-9	23	119.869	21	45.57
9-10	15	123.400	14	42.42
10-11	6	122.333	6	46.66

The above data is shown in graph form in Figure 4.

Figure 5 shows a comparison graph of Dr. Balke's study using as subjects adult males on a treadmill exercise test. As shown the systolic

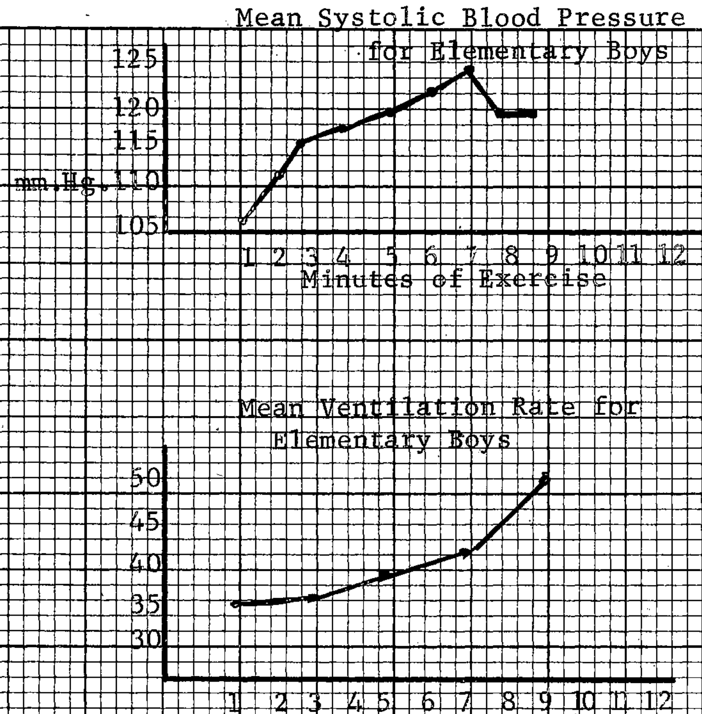

Figure 4. Metabolic Calculations Having a Breaking Point of Seven Minutes

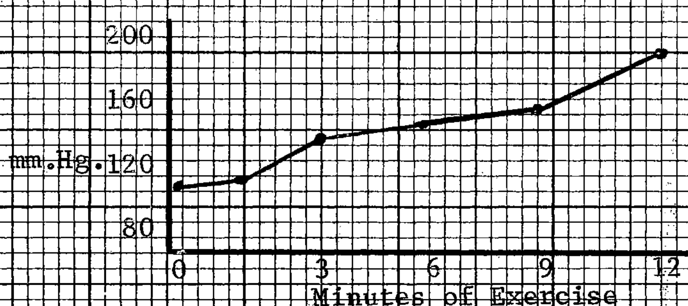

Figure 5. Mean Systolic Blood Pressure Response for Male Employees, Balke'
(Treadmill)

blood pressure rises steadily in almost a linear line. The adults systolic blood pressure starts at a higher level than do the boys, but the rise is at about the same speed.[1]

Figure 4 presents the group mean systolic blood pressures. This graph pictures a rise in mean systolic blood pressure from the start of the test with the subjects having a low of 100.866 mmHg. at the end of one minute of exercise. The subjects were stepping at a height of 4 inches. The rise was terminated when the subjects mean systolic blood pressure reached a high of 123.488 mm.Hg and dropped to 120.259 mm.Hg. This drop as shown in the graph came after the seventh minute of exercise with the subjects stepping at eleven inches on the stepper. Figure 4 also gives a picture of the mean ventilation rate as experienced by the subjects during exercise. Seventy per cent of the subjects had a rather high ventilation rate to start with, due to high anxiety and some hyperventilation derived from this new experience and laboratory environment.

The mean ventilation rate graph shows the rise in mean ventilation rate starting at 33.5 L/min and reaching a breaking point of 45.57 L/min before making a sharp rise. The first six to seven minutes of exercise were well within the individuals aerobic working capacity as demonstrated by the fact there was no decrease or leveling off of the mean ventilation line.

The following table gives the data of mean oxygen percentage content of expired air samples. There was a definite breaking point or leveling

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[1]B. Balke, "Modified Work Capacity Studies in Individuals with and without Coronary Artery Disease," Journal of Sports Medicine, 16 (1964), p. 208.

off of these calculations at the eighth minute of exercise. This particular calculation agreed with the highest number of subjects hitting their crest loads at eight minutes of exercise. Table IV gives the mean oxygen percentage of expired air.

TABLE IV

GROUP MEANS OF OXYGEN PERCENTAGE THROUGHOUT TEST

Minutes of Exercise	Number of Subjects	Oxygen Percentage
0-1	5	19.39
1-2	8	18.48
2-3	24	18.62
3-4	10	17.65
4-5	24	17.96
5-6	12	17.40
6-7	25	17.60
7-8	18	17.40
8-9	20	17.52
9-10	14	17.55
10-11	6	17.66
11-12	0	0.00

The mean oxygen percentage started at a level of 19.39 per cent, after one minute of exercise and steadily dropped to 17.40 per cent before leveling off. This change or level off occurred at the end of the eighth minute. This data will be shown graphically in Figure 6.

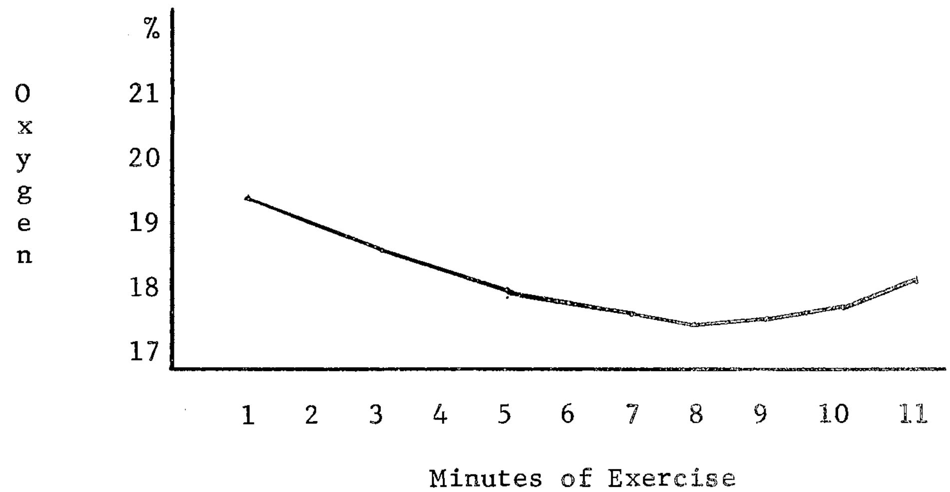

Figure 6. Group Means of Oxygen Percentage Throughout Test

The mean oxygen percentage started at a level of 19.39 per cent after one minute of exercise and steadily dropped to 17.40 per cent before leveling off. This has been reflected in the graph above.

Another set of data that shows a breaking point at eight minutes is carbon dioxide. Table V gives the mean data for this calculation.

In Figure 7 the mean carbon dioxide started at 2.19 per cent after one minute of exercise and climbed to a height of 3.29 per cent where it leveled off for the last three minutes of exercise.

There were several metabolic calculations that did not show any actual change or breaking point. They included respiratory quotient, ventilation corrected, heart rate, diastolic blood pressure and Exercise Metabolic Rate/Sitting Metabolic Rate ratio.

TABLE V

GROUP MEANS OF CARBON DIOXIDE PERCENTAGE THROUGHOUT TEST

Minutes of Exercise	Number of Subjects	Carbon Dioxide Percentage
0-1	5	2.19
1-2	8	2.59
2-3	24	2.51
3-4	9	3.03
4-5	25	2.88
5-6	12	3.28
6-7	25	3.14
7-8	18	3.29
8-9	20	3.20
9-10	14	3.20
10-11	6	3.38

This data is shown in Figure 7.

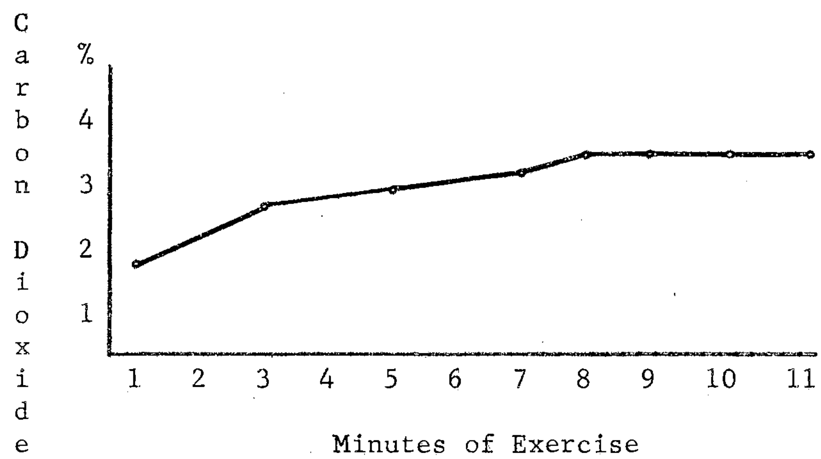

Figure 7. Graph of the Overall Group Mean for Carbon Dioxide Percentage Showing a Breaking Point of Eight Minutes

TABLE VI

OVERALL GROUP MEANS OF THOSE CALCULATIONS
WITH NO OBSERVABLE BREAKING POINT

Minutes of Exercise	Number of Subjects	Ventilation Corrected L/min	Number of Subjects	Respiratory Quotient	Number of Subjects	Heart Rates per 15 sec.	Number of Subjects	Diastolic Blood Pressure mm.Hg.	Number of Subjects	EMR / SMR Ratio
0-1	3	19.88	5	1.19	29	30.55	30	65.13	4	3.16
1-2	8	19.85	8	1.03	30	32.53	30	65.33	8	2.75
2-3	23	18.51	24	1.16	29	34.28	30	67.50	23	2.84
3-4	9	23.79	11	.96	30	36.07	30	67.60	9	4.15
4-5	23	22.96	25	1.11	29	38.05	30	67.50	22	3.95
5-6	12	26.47	12	.93	29	39.21	29	68.10	11	4.73
6-7	24	27.57	25	1.08	28	41.43	29	68.06	24	5.29
7-8	19	31.72	17	1.01	27	42.41	27	67.44	17	6.40
8-9	19	30.53	20	.995	23	43.91	23	66.74	19	6.04
9-10	13	33.10	14	1.05	15	45.07	15	64.0	13	6.96
10-11	6	37.14	6	1.11	7	47.14	6	63.0	6	6.68

The mean respiratory quotient (R.Q.) started at a high of 1.19 and slowly dropped to a level of 1.01 before leveling off for the next three minutes. This respiratory quotient is the ratio of carbon dioxide to oxygen $\frac{CO_2}{O_2}$. During short duration exercise the R.Q. will have a tendency to rise when the exercise is prolonged or exhaustive, the R.Q. goes steadily down. The only explanation that might be given for the type of calculation derived from this study is that the subjects were hyperventilated, thus causing spurious R.Q., resulting from over breathing. The subjects R.Q.'s were high during the early part of the test but dropped off after the exercise started (Figure 7).

Mean corrected ventilation also leveled off after the eighth minute of exercise, but again had a tendency to rise for the next two minutes not showing any true breaking point. This calculation started at a low of 19.88 L/min and rose to 37.14 L/min before all subjects terminated their exercise.

The subjects mean heart rate started at 30.55 for a 15/sec. count or 122.20 pulse rate per minute and climbed steadily terminating at a mean of 180 pulse rate/min. Seven subjects were permitted to go approximately 208 pulse rate/min to find if any oxygen debt was encountered following the crest load of the chosen 180/min heart rate.

As for the mean diastolic blood pressure there was almost no change throughout the exercise period. The diastolic blood pressure started at 65.133 mmHg. and stayed close to this figure with a 67.50 mmHg. at its highest level, where it leveled off for the remaining 3 minutes. The subjects were at this time stepping at a height of eleven inches.

The last group of data in the table gives an expression of energy cost using a ratio of the work metabolic rate and the resting metabolic rate. Work can be considered moderate when its cost is three times that of the resting rate. When the metabolic rate increases eight times, it is considered hard work, but can be maintained for eight hours. Reference to this ratio may be found in Dr. Karpovich and Dr. Weiss writings concerning the $\frac{\text{Work Metabolic Rate}}{\text{Resting Metabolic Rate}}$ Ratio, in prescribing exercises to convalescent patients.[2]

The mean $\frac{\text{EMR}}{\text{SMR}}$ ratio of the subjects in this study started at the end of two minutes of exercise at 2.75 and climbed to 6.96 at the end of ten minutes. On the following page Figure 8 gives a graphic view of the data shown in Table VI.

Means were calculated on all subjects at their observed cut-off points for blood pressure, pulse rates, ventilation rate, carbon dioxide, oxygen and respiratory quotients. The following table shows the means at the cut-off points for the total group.

TABLE VII

OBSERVED MEAN CREST LOAD POINT FOR THE TOTAL GROUP

Tests Given	Means
Systolic Blood Pressure	123.00 mm.Hg.
Diastolic Blood Pressure	68.00 mm.Hg.
Pulse Rate	44-45 per 15 sec.
Ventilation Rate	45.57 per minute
Carbon Dioxide Percentage	3.29 per cent
Oxygen Percentage	17.40 per cent

[2]R. A. Weiss and P. V. Karpovich, "Energy Cost of Exercise for Convalescents," Archives of Physical Medicine, 28 (1947), p. 447.

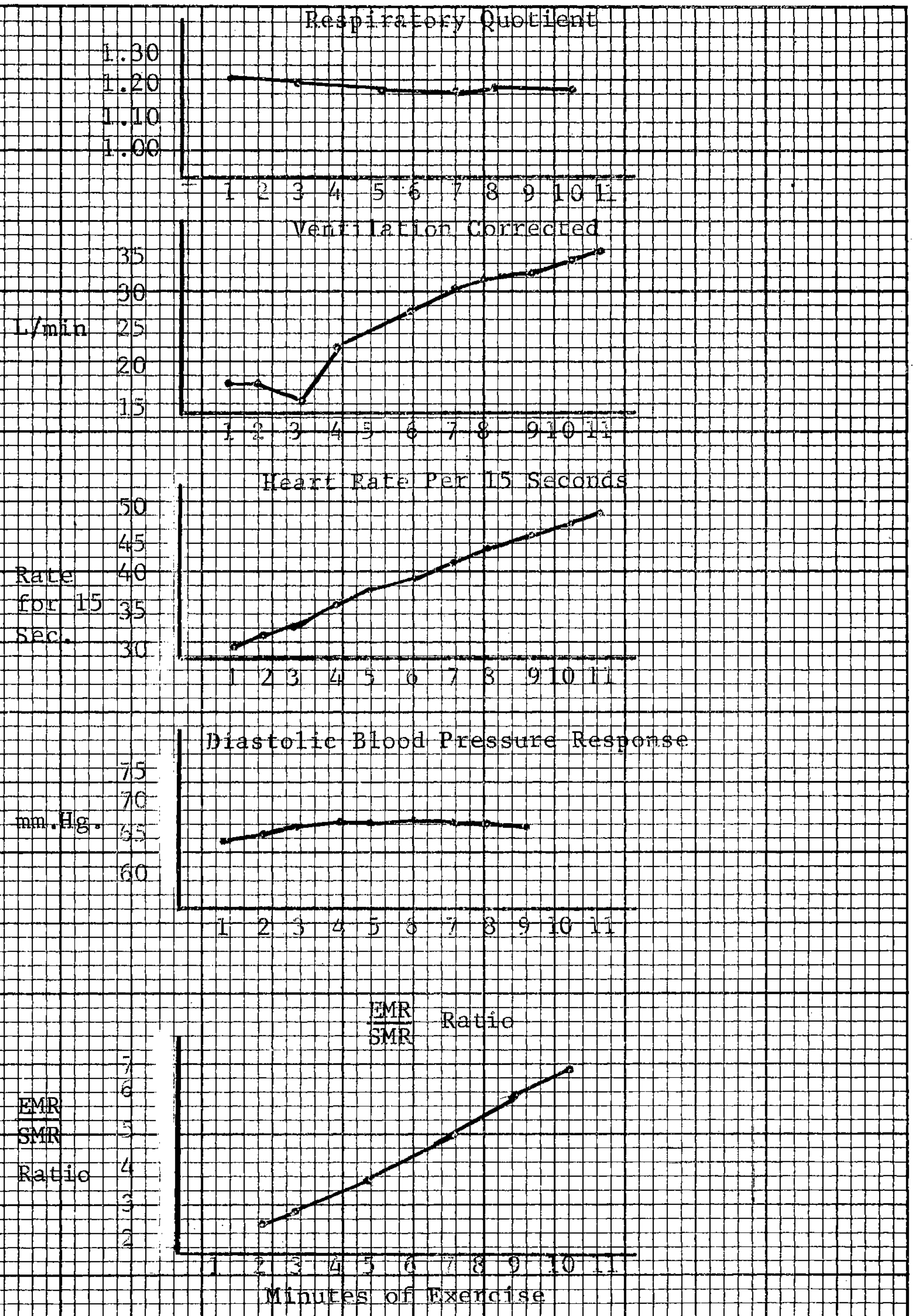

Figure 8. Overall Group Means of Those Calculations with No Observable Breaking Points

These data were called the observed cut-off points because they reflected the points where a rise, level off, or drop occurred in the metabolic data. About seventy-five per cent of the crest load points observed were the same as the crest loads used as cut-off points during the testing.

In the construction of the graphs in this chapter some samples were not drawn on the graphs, because of the small number of scores during these minutes of exercise. Heart rate and blood pressure measurements were taken every minute. Expired air samples were taken on the third, fifth, seventh and every minute thereafter until termination of the exercise.

Some observations made before the actual exercise started, during exercise, and during the recovery stage were these:

1. The subjects had a tendency to be very anxious and hyperventilated evidently due to the environment in which they found themselves and the interest and mystery of what was going to happen to them during the test.

2. It was noticed that some of the boys had some problems in hitting the step when nearing the crest-load time of the test. They seemed to have a tendency to stumble or catch their toe on the end of the stepper.

3. At the end of exercise it was noticed that each boy was perspiring and those boys that went the shortest time had the highest quantity of perspiration on their forehead.

Table VIII includes the mean scores for the VO_2/ml/kg along with the minutes of exercise and number of subjects that the calculations include. If exercise is moderate and uniform, the oxygen intake rises gradually and then levels off and remains at this level for the duration of the exercise. This figure has generally been accepted as being the most valid reflection of endurance among all physiological variables.

TABLE VIII

MEAN OXYGEN INTAKES PER MINUTE

Height of Step (inches)	Minutes of Exercise	Number of Subjects	VO_2/ml/kg
4	0-1	3	9.97
5	1-2	7	11.14
6	2-3	25	12.61
7	3-4	8	15.54
8	4-5	26	19.01
9	5-6	11	20.69
10	6-7	26	25.08
11	7-8	19	28.71
12	8-9	21	31.00
13	9-10	13	28.65
14	10-11	5	29.15

It was necessary to check the reliability of this test procedure. A group of five randomly selected subjects were asked to return to the laboratory after all tests had been given for the first time. At this time only heart rates and blood pressure measurements were taken. The resulting measurements were almost identical to those of the first test indicating that this is a reliable test procedure. The following are the mean scores for those subjects during the first and second test.

TABLE IX

CREST LOAD MEASUREMENTS FROM ORIGINAL TEST AND RETEST

Subjects Tested	Systolic Blood Pressure		Diastolic Blood Pressure		Heart Rate	
Test No.	1st	2nd	1st	2nd	1st	2nd
D.P.	115	115	69	69	43	41
A.P.	131	131	69	69	39	39
B.C.	132	138	70	69	39	40
K.E.	115	117	68	69	42	42
R.M.	150	150	69	70	35	36

It is recommended that when this test is used in the field that three basic pieces of equipment be used: the stepper, a stethoscope with a modified five to six foot tube attached to the listening bell for freedom of movement, and a metronome for speed of step. An assistant may be necessary to trigger the electric motor on the stepper. The instructor after attaching the stethoscope to the chest by means of an athletic wrap or tape, will read the heart rate while subject is stepping. He can also record these heart rates while exercise is in progress. The subject should be stopped when he reaches a heart rate of 45 beats for a fifteen second count.

The table on the following page gives norms that have been calculated with the data from the thirty subjects in the study.

TABLE X

METABOLIC FUNCTIONAL CAPACITY STEP TEST NORMS
FOR BOYS 8-12 YEARS OF AGE

Minutes of Exercise	Height of Step	Functional Capacity Classification	Estimated VO_2/ml/kg
0 - 3	4-6 inches	Very Poor	12.61
4 - 5	7-8 inches	Poor	19.01
6 - 7	9-10 inches	Fair	25.08
8 - 9	11-12 inches	Good	31.00
10 - 11	13-14 inches	Excellent	34.00
12 - Above	15-Above	Superior	37.00

One additional way the heart rates might be recorded is by the use of a small diaphragm microphone, attached to the subject's chest, connected to a tape recorder. By this means the instructor might have a taped record of the heart rate of the subject. To know when to terminate the test, flashes of the electric eye found on many tape recorders could be counted per minute to make sure the test remained sub-maximal.

When aerobic resynthesis of energy stores cannot keep pace with their utilization in skeletal muscle, energy needs are met for short periods by anaerobic glycolysis and an oxygen debt is incurred. This study was a sub-maximal test. Some of the subjects were permitted to go a minute or two past the crest-load to find if they developed very much oxygen debt. The oxygen debts incurred were minimal. The range was from .0324 to 1.4495 liters with a mean of .6295 liters. Some of the readings were so low there was almost no oxygen debt.

CHAPTER V

CONCLUSIONS AND RECOMMENDATIONS

This study has produced data that will give the physical educator in the field and the researcher in the laboratory additional information with which to measure the metabolic functional capacity of upper elementary boys. Chapter II (Review of Literature) pointed out a number of factors, in some detail which have been thought of as having need for additional research. With the metabolic data backing up the validation of this particular test it is assumed to be a valid test of endurance.

The writer of this study has gained considerable insight in regard to the need for such a test in the field of physical education. There has been a need for a test with good physiological validity to measure endurance. The test itself was very interesting to the subjects tested. In fact this became somewhat of a problem during the testing procedure in that the subjects became so interested in what was done around them, they lost their concentration on the stepping height and cadence. This was the reason for much of the hyperventilation some of the boys experienced. With so much interest prevailing this test could be used as a motivational device throughout the course of the school year.

Quotations raised earlier in this study expressed the need to have a valid test of endurance as well as an inexpensive one. It may be in the future that a stepper of the type used in this test would be mass produced, thus cutting down on the cost of the stepper. With some training in the use of a stethoscope and the taking of heart rates an instructor in the field could test a different student on the average of every ten minutes in class. With a total fitness testing program being followed through, this test of endurance could be one facet of a circuit testing program.

Figures 4, 5 and 6 show ample data that the crest-load for these thirty subjects came within the seventh to ninth minute with the highest percentage falling at the eighth minute. With the retest being so close in relationship to the full testing procedures it is assumed that the taking of heart rates would be all that would be necessary for giving this test. The time element of how long it takes a subject to reach a heart rate of 44 to 45 for fifteen seconds would be an indication of the subjects metabolic functional capacity. Also the height of the step before he reached the above heart rate would also be an indication of the bodies ability to re-balance to resting metabolism after termination of the exercise. The variable here would be the time factor of return to resting heart rate.

On the basis of the data collected in this study the following conclusions were made:

1. This test offers a valid measure of functional metabolic capacity.

2. This test procedure is reliable.

3. As a field test, using length of time to reach cut-off point, only pulse rates need to be monitered.

4. A pulse rate of 180 beats per min (45/15 sec) is recommended as the cut-off point for the age group of boys, 8-12.

5. There was very little oxygen debt incurred in performing this

test. (Mean .6295 liters)

6. Mean energy cost at crest load was 6.4 times resting rate or approximately 31 m./O_2/kg body weight.

Recommendations

The following recommendations for using the Metabolic Functional Capacity Step Test as an instrument for the testing of endurance in the physical education classroom by an instructor of physical education can be made as a result of this study:

1. It is necessary in most programs to have some type of screening device to evaluate the students physical fitness. The recommendation is made that this test be used for one facet of physical fitness, that of endurance.

2. The test could be used as a motivational device for the students to better their scores through physical conditioning by improving their performance.

3. After testing the students the scores should be compared with the table of norms to let the student know where he stands in comparison with the above or below average scores.

4. By comparing the scores with those on the norm table the instructor can ascertain if the student needs additional work on this phase of the total fitness program.

5. The student should be encouraged to better their individual scores in competition with themselves rather than with other individuals in the class.

6. This type of testing could be given at the beginning of a semester

to determine the improvement in individual scores and to evaluate the program.

Recommendations for Further Study

The following recommendations for further investigations of the Metabolic Functional Capacity Step Test as an instrument of testing for endurance in physical education are made as a result of this study:

1. a study should be made with more subjects taken by random sampling for comparison with this study.

2. an investigation using the same procedures with two changes: a. The step stay a certain height, maybe 12 inches, and b. the speed of the metronome be changed every minute to speed up the subject as time is increased. Correlate both studies to see if a motorized stepper is necessary.

3. a similar study should be made with all test being taken, but in surroundings familiar to the subjects being tested. This may cut down on high anxiety before test procedure begins.

4. an investigation identical in nature but in another geographical location to ascertain and compare standards of performance with the geographic location of this study.

5. a study using the same test should be made for girls of same age and grade level. Norms should be made available.

6. an investigation should be made as to what relationship factors such as mental age, height, environment, eating habits, etc. have to do with the metabolic functional capacity.

7. validity and norms should be established in more depth using this test on high school age students.

8. correlate this study with another using a treadmill test that has been validated for endurance testing.

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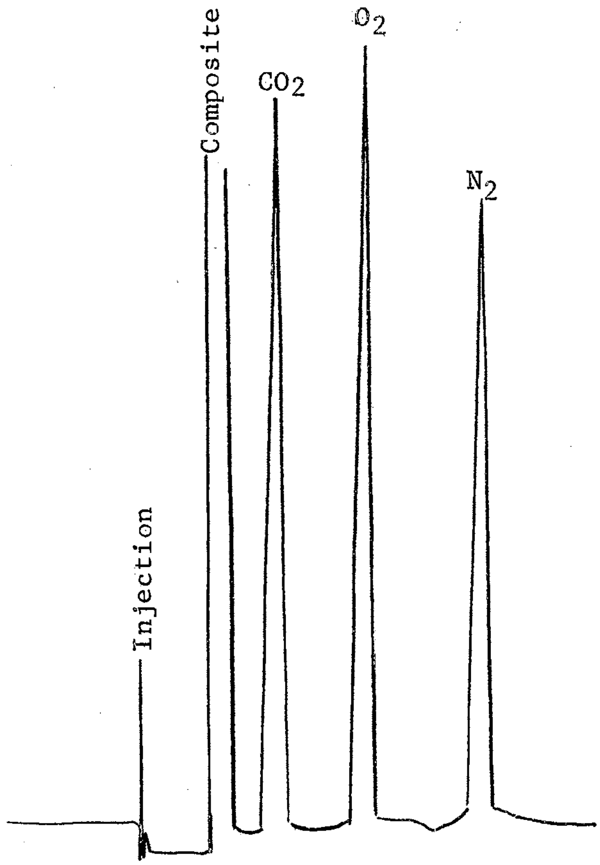
A P P E N D I X

A TYPICAL CHROMATOGRAM OF A MIXTURE CONTAINING CO_2, O_2 and N_2



When a mixture of gases is introduced into the chromatograph, it is swept through the two chromatographic columns by a continuous flow of helium carrier gas. All components of the gas sample except carbon dioxide, are swept quickly through several separating columns. Each gas is detected and recorded on a chromatogram. Each gas can then be identified by its position on the chromatogram, and its concentration determined from the peak height. The composite peak is of no analytical significance.

Subject Participating in Test

LABORATORY METABOLIC CALCULATION

Subject:______________________________ Date:______________________

Age:__________ Somatotype No.:____________ B.P. (mm. Hg.):__________

Height:________ Weight:__________ O.C. Temperature:________________

Surface Area:____________ Correction factor by Harvard line chart:__________

A. Sitting (non-basal)

1. RQ = __________ (from Harvard line chart)
2. Ventilation/min.= $\frac{\_\_\_\_\_\_}{10}$ mm (from Kymograph)= ______ x 1.332= _____ L./min.
3. True O_2 x ventilation = $\frac{x}{100}$ = ________ L./min. of O_2

   Corrected O_2= ______ x ______ = ________ L./min. O_2 - Intake
4. S.M.R. = $\frac{x\ 5^{*}\ x\ 60}{Sq.\ m.}$ = __________ Cal./Hr./Sq.m.

B. O_2-Debt and Rate of O_2-Debt

1. First bag of recovery gas:

   Ventilation/min.= $\frac{\_\_\_\_\_\_}{10}$ mm (from Kymograph)x 1.332 = ________ Liters/min.

   True O_2 x vent.

   $\frac{x}{100}$ = __________ Liters or __________ L./min.
2. Second bag of recovery gas:

   Ventilation/min.= $\frac{\_\_\_\_\_\_}{10}$ mm (from Kymograph) x 1.332 = ________ Liters/min.

   True O_2 x vent.

   $\frac{x}{100}$ = __________ Liters or __________ L./min.
3. Third bag of recovery gas:

   Ventilation/min.= $\frac{\_\_\_\_\_\_}{10}$ mm (from Kymograph) x 1.332 = ________ Liters/min.

   True O_2 x vent.

   $\frac{x}{100}$ = __________ Liters or __________ L./min.
4. Gross O_2-Debt = ________ + ______ = ______ Liters
5. Net O_2-Debt = Gross - Sitting equivalent = ________ - ________ = _____ Liters

SAMPLE CALCULATION FOR FOR EXERCISE PHASES OF TEST

Name________________________ Date________________________

Exercise____________________ Speed____________ Height________

Time________________________

1. RQ = __________ (from Harvard line chart)
2. Ventilation/min. = $\frac{\_\_\_\_\_\_\_\_}{10}$ mm = __________ x 1.332 = ______ L./min.

   Corrected ventilation = $\frac{\text{Corr. factor x vent.}}{\_\_\_\_\_ \text{ x } \_\_\_\_\_}$ = ________ L./min.
3. Gross O_2-Intake = True O_2 x ventilation = $\frac{x}{100}$ = ________ L./min.
4. E.M.R. = $\frac{\text{x 5* x 60}}{\text{Sq. m.}}$ = __________ Cal./Hr./Sq.m.
5. Intensity of Exercise = $\frac{\text{x 300}}{\text{Kg.}}$ = __________ Cal./Hr./Kg.

Exercise____________________ Speed____________ Height________

Time________________________

1. RQ = __________ (from Harvard line chart)
2. Ventilation/min. = $\frac{\_\_\_\_\_\_\_\_}{10}$ mm = __________ x 1.332 = ______ L./min

   Corrected ventilation = $\frac{\text{Corr. factor x vent.}}{\_\_\_\_\_ \text{ x } \_\_\_\_\_}$ = ________ L./min.
3. Gross O_2-Intake = True O_2 x ventilation = $\frac{x}{100}$ = ________ L./min.
4. E.M.R. = $\frac{\text{x 5* x 60}}{\text{Sq. m.}}$ = __________ Cal./Hr./Sq.m.
5. Intensity of Exercise = $\frac{\text{x 300}}{\text{Kg.}}$ = __________ Cal./Hr./Kg.

Exercise____________________ Speed____________ Height________

Time________________________

1. RQ = __________ (from Harvard line chart)
2. Ventilation/min. = $\frac{\_\_\_\_\_\_\_\_}{10}$ mm = __________ x 1.332 = ______ L./min.

   Corrected ventilation = $\frac{\text{Corr. factor x vent.}}{\_\_\_\_\_ \text{ x } \_\_\_\_\_}$ = ________ L./min.
3. Gross O_2-Intake = True O_2 x ventilation = $\frac{x}{100}$ = ________ L./min.
4. E.M.R. = $\frac{\text{x 5* x 60}}{\text{Sq. m.}}$ = __________ Cal./Hr./Sq.m.
5. Intensity of Exercise = $\frac{\text{x 300}}{\text{Kg.}}$ = __________ Cal./Hr./Kg.

WORK CAPACITY TEST

Ht. of Step at Start: 4 "

Name: D. F.

Age: 7 Height: 52 Weight: 67

Abdominal 5 Subscapular 7.5

Temp: 21 Triceps Measure: 8

Bar Pr: 739 Vital Capacity: 190

RGS: 29 LGS: 22

S.A. 1.09 C.F. .887

Type Test: Step Sex: M x F

min.	Bag Nr.	Syst/ Diast	Pulse	Vent Kym.	Vent Corr.	Vent Rate	Tidal V/L	CO_2	O_2	RQ	True O_2	EMR SMR	
Rest		84/ /68	19	93		13		2.52	19.1	1.4	1.75		
0-1	1	90/ /71	30	136	16.08	28	.5743	2.4	19.05	1.3	1.85	81.8256 / 52.899	1.546
1-2		92/ /70	31										
2-3	2	94/ /70	33	164	19.37	40	.4842	2.7	19.0	1.5	1.76	93.8531 / 52.899	1.774
3-4		98/ /71	37										
4-5	3	104/ 70	38	220	25.99	40	.6498	2.81	18.5	1.21	2.30	164.5320 / 52.899	3.110
5-6		104/ 70	40										
6-7	4	110/ /69	42	228	26.94	40	.6735	3.21	16.9	1.6	2.97	220.1834 / 52.899	4.162
7-8		99/ /70	44										
8-9	5	98/ /70	45	200	23.63	44	.5370	2.9	17.7	.86	3.31	215.2568 / 52.899	4.069
9-10													
10-11													
11-12													
12-13													
13-14													
14-15													
15-16													
16-17													
17-18													
Rec. 0-1		120/ /70	18	160	18.90	36.	.5250	2.62	18.	.86	3		
0-2		100/ /70	25	52	6.15	20	.3075	2.55	18.20	.92	2.75		
0-3		98/ /70	26	56	6.62	24	.2758	2.45	18.2	.86	2.80		
0-4	13 13	1291 / 909	99.31 / 69.92										
Net O_2 Debt		.2610											

WORK CAPACITY TEST

Ht. of Step at Start: 4"

Name: J. F.

Age: 9 Height: 4' 7" Weight: 104

Abdominal 19 Subscapular 18
Temp: 24 Triceps Measure: 24
Bar Pr: 740 Vital Capacity:
RGS: 42 LGS: 33
S.A. 1.31 C.F. .875
Type Test: Step Sex: M X F

min.	Bag Nr.	Syst/ Diast	Pulse	Vent Kym.	Vent Corr.	Vent Rate	Tidal V/L	CO_2	O_2	RQ	True O_2	EMR SMR	
Rest		112/60	25	74		31		2.41	19.6	1.65	1.40		
0-1		122/65	37										
1-2		130/70	38										
2-3	1	130/75	41	200	23.31	36	.6475	2.62	19.2	1.55	1.65	88.08 / 27.66	3.18
3-4	2	130/75	43	284	33.10	44	.7523	3.5	18.	1.25	2.77	209.98 / 27.66	7.59
4-5	5	130/75	45	272	31.70	40	.7925	3.55	17.8	1.17	3.01	218.52 / 27.66	7.90
5-6	6	130/75	45	284	33.10	36	.9194	3.6	17.8	1.19	3.0	227.40 / 27.66	8.22
6-7	8	125/70	46	304	35.43	36	.9842	3.61	17.9	1.25	2.87	232.85 / 27.66	8.42
7-8	9	120/70	49	344	40.09	48	.8352	3.5	18	1.26	2.76	253.40 / 27.66	9.16
8-9													
9-10													
10-11													
11-12													
12-13													
13-14													
14-15													
15-16													
16-17													
17-18													
Rec. 0-1	10	125/70	39	204	23.77	32	.7428	3.18	18.6	1.52	2.10		
0-2	11	115/70	36	224	26.11	36	.7253	2.72	21.2				
0-3	12	110/70	36	180		28							
0-4													
Net O_2 Debt	.3790												

WORK CAPACITY TEST

Ht. of Step at Start: 4"

Name: E.S.

Age: 9 Height: 4'10" Weight: 87½ (39.8) Type Test: Step Sex: M X F

Abdominal 3 Subscapular 4
Temp: 26 Triceps Measure: 5
Bar Pr: 736 Vital Capacity: 115
RGS: 35 LGS: 32
CF-.864

min.	Bag Nr.	Syst/ Diast	Pulse	Vent Kym.	Vent Corr.	Vent Rate	Tidal V/L	CO_2	O_2	RQ	True O_2	EMR SMR	
Rest		106/64	80	53.	.0951	17	.0056	2.3	19.4	1.5	1.56	22.29	
0-1		110/70	30										
1-2		110/75	31										
2-3	1	110/70	32	136	15.66	28	.5593	2.65	19.3	1.7	1.55	56.88/22.29	2.55
3-4		120/70	34										
4-5	2	125/70	36	164	18.87	32	.5897	2.95	18.7	1.45	1.40	90.21/22.29	4.08
5-6		130/70	36										
6-7	3	130/70	37	176	20.25	28	.7232	3.1	19.3	2.15	1.40	66.44/22.29	2.98
7-8		130/70	40										
8-9	4	125/70	43	240	27.62	36	.7672	3.4	18.2	1.33	2.55	165.07/22.29	7.41
9-10	5	128/70	45	280	32.23	36	.8953	3.5	18.2	1.36	2.55	192.63/22.29	8.64
10-11	6	135/65	50	268	30.84	36.	.8567	3.4	18.5	1.55	2.10	158.30/22.29	7.10
11-12													
12-13													
13-14													
14-15													
15-16													
16-17													
17-18													
Rec. 0-1	7	120/65	31	144	76.57	28	.5918	2.95	21.2	1.83	2.16		
0-2	8	115/70	26	128	14.73	28	.5261	2.6	17.9	1.72	1.94		
0-3	9	105/70	26	116	13.35	28	.4768	2.2	18.4	1.6	1.80		
0-4	15/	1799/1039	119.93/69.27										
Net O_2 Debt		.7889											

WORK CAPACITY TEST

Ht. of Step at Start: 4"

Name: J. K.

Age: 9 Height: 53½" Weight: 53

Abdominal 4 Subscapular 5

Temp: 21 Triceps Measure: 3

Bar Pres. 732 Vital Capacity: 130

[illegible] 34 [illegible] 35

S.A. 1.06 C.F. .879

Type Test: Step Sex: M X F

min.	Bag Nr.	Syst/ Diast	Pulse	Vent Kym.	Vent Corr.	Vent Rate	Tidal V/L	CO_2	O_2	RQ	True O_2	EMR SMR	
Rest		100/52	24	107		16		1.92	20.2	1.7	.80	28.36	
0-1		100/60	29										
1-2		110/55	32										
2-3	1	118/60	33	160	18.73	24	.7804	2.	20.2	1.65	.90	47.71 / 28.36	1.68
3-4	X	118/60	36										
4-5	2	120/65	36	164	19.20	32	.6000	2.45	19.2	1.45	1.75	95.10 / 28.36	3.35
5-6	X	120/65	36										
6-7	4	125/65	40	284	33.25	38.2	.8750	2.2	18.8	1.06	2.10	197.60 / 28.36	6.97
7-8	5	125/65	41	280	32.78	44	.7450	3	18.5	1.32	2.25	208.75 / 28.36	7.36
8-9	6	130/65	42	284	33.25	44	.7557	3	18.6	1.37	2.18	205.13 / 28.36	7.23
9-10	7	120/60	45	232	27.16	44	.6173	2.95	18.6	1.37	2.15	165.25 / 28.36	5.83
10-11													
11-12													
12-13													
13-14													
14-15													
15-16													
16-17													
17-18													
Rec. 0-1	8	120/60	28	60	7.025	12	.5854	2.05	19.4	1.25	1.65		
0-2	9	110/65	28	76	8.895	20	.4448	2.22	19.2	1.3	1.70		
0-3	10	110/70	25	64	7.493	12	.6244	1.4	20.3	1.25	1.00		
0-4													
Net O_2 Debt	.0423												

2nd Test

WORK CAPACITY TEST

Ht. of Step at Start: 4 "

Name: A. P.

Abdominal______ Subscapular______
Temp:______ Triceps Measure:______
Bar Pr:______ Vital Capacity:______
RGS:______ LGS:______

Age:______ Height:______ Weight:______ Type Test:______ Sex: M___ F___

min.	Bag Nr.	Syst/ Diast	Pulse	Vent Kym.	Vent Corr.	Vent Rate	Tidal V/L	CO_2	O_2	RQ	True O_2	EMR SMR
Rest		112/63	28									
0-1		107/67	33									
1-2		125/68	34									
2-3		127/69	36									
3-4		129/70	36									
4-5		134/70	38									
5-6		136/70	41									
6-7		139/70	42									
7-8		140/70	42									
8-9		136/70	43									
9-10		135/70	44									
10-11		134/70	46									
11-12												
12-13												
13-14												
14-15												
15-16												
16-17												
17-18												
Rec. 0-1		133/68										
0-2		130/66										
0-3		126/62										
0-4												
Net O_2 Debt												

WORK CAPACITY TEST

Abdominal: 9 | Subscapular: 9
Temp: 22 | Triceps Measure: 17
Bar Pr: 742 | Vital Capacity: 135
RGS: 35 | LGS: 35

Ht. of Step at Start: 4"

Name: M. F.

S.A. 1.29 | C.F. .888

Age: 9 | Height: 4' 8" | Weight: 93½ | Type Test: Step | Sex: M X F

min.	Bag Nr.	Syst/ Diast	Pulse	Vent Kym.	Vent Corr.	Vent Rate	Tidal V/L	CO_2	O_2	RQ	True O_2	EMR SMR	
Rest		104/68	29	56		18		2.95	18.7	1.46	2.01		
0-1		105/70	38										
1-2	1	110/70	40	184	21.76	40	.5440	2.97	18.6	1.38	2.15	$\frac{108.74}{30.95}$	3.51
2-3		115/70	39										
3-4	2	115/75	44	192	22.71	32	.7097	3.02	18.4	1.24	2.40	$\frac{126.74}{30.95}$	4.09
4-5	4	118.75	45	196	23.185	36	.6440	3.02	19.3	2.05	1.45	$\frac{78.18}{30.95}$	2.53
5-6	5	110/80	48	224	26.50	40	.6625	3.3	18.1	1.21	2.70	$\frac{166.40}{30.95}$	5.38
6-7	6	110/80	50	244	28.86	44	.6559	3.32	18.	1.17	2.82	$\frac{189.26}{30.95}$	6.11
7-8													
8-9													
9-10													
10-11													
11-12													
12-13													
13-14													
14-15													
15-16													
16-17													
17-18													
Rec. 0-1	7.	115.70	30	104	12.30	24	.5125	2.8	18.6	1.26	2.20		
0-2	8	112/75	30	72	8.52	24	.3550	2.3	19.1	1.32	1.75		
0-3	9	108/75	29	72	8.516	20	.4258	2.15	19.4	1.35	1.64		
0-4													
Net O_2 Debt	.1601												

WORK CAPACITY TEST

Ht. of Step at Start: 4"   Abdominal 6   Subscapular 5
Temp: 23   Triceps Measure: 4
Bar Prs: 741   Vital Capacity: 110
Name: S. T.   RGS: 35   LGS: 30
S.A. 1.09   C.F. .882
Age: 9   Height: 53¼"   Weight: 63   Type Test: Step   Sex: M X F ___

min.	Bag No.	Syst/ Diast	Pulse	Vent Kym.	Vent Corr.	Vent Rate	Tidal V/L	CO_2	O_2	RQ	True O_2	EMR SMR	
Rest		98/68	24	65		28		2.7	19	1.55	1.75		
0-1		110/60	32										
1-2		114/65	33										
2-3	1	115/70	33	152	17.86	40	.4465	2.6	19.1	1.51	1.73	85.05 / 36.77	2.31
3-4		115/70	35										
4-5	2	112/70	39	188	22.41	44	.5093	2.7	18.8	1.37	1.95	120.28 / 36.77	3.27
5-6	5	110/70	40	204	23.96	48	.4992	3	18.6	1.4	2.14	141.11 / 36.77	3.84
6-7	6	110/70	44	204	23.96	48	.4992	3.2	18.35	1.31	2.40	158.26 / 36.77	4.30
7-8	7	110/65	46	208	24.44	44	.5554	3.1	18.5	1.36	2.25	151.35 / 36.77	4.17
8-9	8	110/65	47	256	30.08	52	.5785	3.18	18.45	1.36	2.30	190.40 / 36.77	5.18
9-10													
10-11													
11-12													
12-13													
13-14													
14-15													
15-16													
16-17													
17-18													
Rec. 0-1	9	120/65	26	108	12.68	32	.3962	2.65	19.2	1.56	1.70		
0-2	10	110/65	26	60	7.049	28	.2518	2.1	19.6	1.4	1.50		
0-3	11	103/65	27	64		28		1.51	20.7				
0-4													
Net O_2 Debt	.0541												

WORK CAPACITY TEST

Ht. of Step at Start: 4

Name: B. H.

Age: 10 Height: 4' 8" Weight: 87

Abdominal 10 Subscapular 9
Temp: 21 Triceps Measure: 5
Bar Pr: 740 Vital Capacity: 130
RGS: 50 LGS: 45
S.A. 1.27 C.F. .890
Type Test: Step Sex: MX F

min.	Bag Nr.	Syst/ Diast	Pulse	Vent Kym.	Vent Corr.	Vent Rate	Tidal V/L	CO_2	O_2	RQ	True O_2	EMR SMR	
Rest		104/68	18	60		20		2.9	19.0	1.69	1.70		
0-1		105/65	29										
1-2		110/75	30										
2-3	1	115/75	32	188	22.29	32	.6966	2.95	18.9	1.65	1.79	52.65 / 20.27	2.60
3-4		125/70	35										
4-5	2	125/70	37	220	26.08	36	.7244	3.5	18.9	1.85	1.90	108.425 / 20.27	5.40
5-6		125/70	38										
6-7	4	130/70	39	268	31.77	44	.7220	3.41	18.0	1.21	2.80	125.339 / 20.27	6.18
7-8		135/65	41										
8-9	5	130/65	45	320	37.93	56	.6773	3.51	18.1	1.31	2.65	170.244 / 20.27	8.40
9-10	6	125/65	49	332	39.36	52	.7569	3.71	17.9	1.3	2.85	182.220 / 20.27	8.99
10-11													
11-12													
12-13													
13-14													
14-15													
15-16													
16-17													
17-18													
Rec. 0-1	7	115/75	22	88	10.43	28	.7911	3.1	18.1	1.12	2.75		
0-2	9	110/70	19	68	16.12	18	.8956	3.1	18.3	1.13	2.50		
0-3	10	110/70	20	76	9.0	16	.5625	2.85	18.4	1.16	2.42		
0-4													
Net O_2 Debt	.3820												

WORK CAPACITY TEST

Ht. of Step at Start: 4"

Name: B. I.

Abdominal 5 Subscapular 6
Temp: 21 Triceps Measure: 4
Bar Pr: 736 Vital Capacity: 120
RGS: 40 LGS: 44
SA 1.14 C.F. .883

Age: 10 Height: 4' 5" Weight: 73 lbs. Type Test: Step Sex: M X F ___

min.	Bag Nr.	Syst/ Diast	Pulse	Vent Kym.	Vent Corr.	Vent Rate	Tidal V/L	CO_2	O_2	RQ	True O_2	EMR SMR	
Rest		95/65	68	149		27		1.65	19.9	1.15	1.35		
0-1		95/65	24										
1-2		105/60	28										
2-3	2	110/60	32	112	13.17	24	.5488	1.65	19.9	1.15	1.35	46.79 / 62.24	.7549
3-4		120/60	32										
4-5	3	130/60	32	184	21.63	44	.4916	2.83	19.	1.62	1.75	99.60 / 62.24	1.60
5-6		135/60	37										
6-7	4	140/65	39	204	27.17	40	.6792	2.85	18.05	1.22	2.30	145.21 / 62.24	2.33
7-8	5	130/65	39	204	23.99	40	.5998	3.5	17.8	1.15	3.04	191.89 / 62.24	3.08
8-9	6	130/65	44	260	30.58	52	.5881	3.0	18.	1.03	2.87	230.95 / 62.24	3.71
9-10	7	130/60	46	272	31.99	52	.6152	2.92	18.1	1.03	2.80	235.71 / 62.24	3.79
10-11													
11-12													
12-13													
13-14													
14-15													
15-16													
16-17													
17-18													
Rec. 0-1	8	115/60	29	140	16.47	32	.5147	2.36	19.0	1.30	1.84		
0-2	9	110/65	28	80	9.41	16	.5881	2.13	19.2	1.17	1.80		
0-3	10	110/65	28	140	16.47	24	.6862	1.89	19.9	1.4	1.20		
0-4													
Net O_2 Debt	.0395												

WORK CAPACITY TEST

Abdominal 9 Subscapular 9

Ht. of Step at Start: 4" Temp: 23 Triceps Measure: 5.5

Bar Pr: 741 Vital Capacity: 156

Name: R. W. RGS: 40 LGS: 37

S.A. 1.14 C.F. .882

Age: 10 Height: 4' 4" Weight: 72 Type Test: Step Sex: M X F

min.	Bag Nr.	Syst/ Diast	Pulse	Vent Kym.	Vent Corr.	Vent Rate	Tidal V/L	CO_2	O_2	RQ	True O_2	EMR SMR	
Rest		94/62	17	152	.0870	16	.0054	2.85	18.8	1.45	1.95		
0-1		90/60	26					2.7	18.7	1.29	2.10	121.21 / 2289	5.29
1-2		98/65	30										
2-3	1	105/75	30	160	18.80	32	.5875	2.9	18.4	1.17	2.45	182.95 / 22.89	7.99
3-4		110/75	31										
4-5	2	115/70	35	148	17.38	44	.3950	3.12	17.1	.77	4.0	302.10 / 22.890	13.19
5-6		115/70	37										
6-7		115/70	39										
7-8		105/70	39										
8-9	6	105/70	42	236	27.73	52	.5333	2.91	17.05	.7	4.14	302.10 / 22.89	13.19
9-10	7	105/65	40	220	25.84	44	.5873	2.81	18.6	1.29	2.19	148.92 / 22.89	6.50
10-11													
11-12													
12-13													
13-14													
14-15													
15-16													
16-17													
17-18													
Rec. 0-1	8	120/70	21	60	7.049	20	.3524	2.51	18.5	1.04	2.40		
0-2	9	110/65	20	68	7.989	32	.2496	2.4	18.2	.85	2.80		
0-3	10	108/65	19	60	7.049	20	.3524	2.5	18.8	1.25	2.0		
0-4													
Net O_2 Debt		1.4495											

WORK CAPACITY TEST

Abdominal 10 Subscapular 9

Ht. of Step at Start: 4" Temp: 20 Triceps Measure: 9

Bar Pr: 743 Vital Capacity: 110

Name: D. D. RGS: 41 LGS: 40

SA 1.48 C.F. .897

Age: 10 Height: 4'8" Weight: 129 lbs. Type Test: Step Sex: M X F

min.	Bag Nr.	Syst/ Diast	Pulse	Vent Kym.	Vent Corr.	Vent Rate	Tidal V/L	CO_2	O_2	RQ	True O_2	EMR SMR	
Rest		110/68	26	188		19.96		1.95	18.6	.81	2.40		
0-1		110/68	34			36.							
1-2		118/70	38										
2-3	2	122/70	40	168	20.07	40	.5018	2.35	18.2	.83	2.80	113.92 / 109.277	1.04
3-4		124/70	43										
4-5	3	122/70	48	208	24.86	52	.4781	2.9	17.5	.80	3.56	179.39 / 109.277	1.64
5-6													
6-7													
7-8													
8-9													
9-10													
10-11													
11-12													
12-13													
13-14													
14-15													
15-16													
16-17													
17-18													
Rec. 0-1	4	134/70	36	88	10.515	28	.3755	2.6	17.7	.76	3.38		
0-2	5	132/68	33	88	10.515	28	.3755	2.69	17.6	.76	3.50		
0-3	6	124/68	31	60	9.169	24	.3820	2.49	17.8	.75	3.29		
0-4													
Net O_2 Debt	.79757												

WORK CAPACITY TEST

Ht. of Step at Start: 4"

Name: E. H.

Age: 10 Height: 58 / 4'8" Weight: 39.5 / 87

Abdominal 10 Subscapular 9
Temp: 21 Triceps Measure: 5
Bar Pr: 740 Vital Capacity: 130
RGS: 50 LGS: 45
SA-1.27 CF. 890
Type Test: Step Sex: M X F

min.	Bag Nr.	Syst/ Diast	Pulse	Vent Kym.	Vent Corr.	Vent Rate	Tidal V/L	CO_2	O_2	RQ	True O_2	EMR SMR	
Rest		104/68	18	60		20		2.9	19.0	1.69	1.70		
0-1		105/65	29										
1-2		110/75	30										
2-3	1	115/75	32	188	22.29	32	.6966	2.95	18.9	1.65	1.79	52.65/20.27	2.60
3-4		125/70	35										
4-5	2	125/70	37	220	26.08	36.	.7244	3.5	18.7	1.85	1.90	108.425/20.27	5.40
5-6		125/70	38										
6-7	4	130/70	39	268	31.77	44	.7220	3.41	18.0	1.21	2.80	125.339/20.27	6.18
7-8		135/65	41										
8-9	5	130/65	45	320	37.93	56	.6773	3.51	18.1	1.31	2.65	170.244/20.27	8.40
9-10	6	125/65	49	332	39.36	52	.7569	3.71	17.9	1.3	2.85	182.220/20.27	8.99
10-11													
11-12													
12-13													
13-14													
14-15													
15-16													
16-17													
17-18													
Rec. 0-1	7	115/75	22	88	10.43	28	.7911	3.1	18.1	1.12	2.75		
0-2	9	110/70	19	136	16.12	18	.8956	3.1	18.3	1.13	2.50		
0-3	10	110/70	20	76	9.0	16	.5625	2.85	18.4	1.16	2.42		
0-4		1664/973	118.86/69.5										
Net O_2 Debt													

WORK CAPACITY TEST

Ht. of Step at Start: 4"

Name: S.B.

Abdominal: 13 Subscapular: 11
Temp: 21 Triceps Measure: 10
Bar Prs: 736 Vital Capacity: 164
DBS: 47 WBS: 45
S.A. 1.42 C.F. .883

Age: 11 Height: 5' 1" Weight: 104 Type Test: Step Sex: M X F

min.	Bag Nr.	Syst/ Diast	Pulse	Vent Kym.	Vent Corr.	Vent Rate	Tidal V/L	CO_2	O_2	RQ	True O_2	EMR SMR	
Rest		104/69	24	84	.1709	17	.0100	3.61	18.8	2.1	1.73	36.11	
0-1		108/75	27										
1-2		110/75	31										
2-3	1	110/70	34	168	19.76	24	.8233	3.56	18.6	1.77	2.00	83.49 / 36.11	2.31
3-4		115/70	35										
4-5	2	120.70	36					3.28	17.7	1.01	3.21	36.11	
5-6		120/70	38										
6-7	4	120/70	42	284	33.40	36	.9278	3.3	17.64	.99	3.30	232.86 / 36.11	6.45
7-8	5	110/70	44	284	33.40	32	1.0438	3.55	17.4	1.0	3.54	249.80 / 36.11	6.92
8-9	6	110/70	46	292	34.33	40	.8582	3.6	17.2	.95	3.76	272.70 / 36.11	7.55
9-10													
10-11													
11-12													
12-13													
13-14													
14-15													
15-16													
16-17													
17-18													
Rec. 0-1	7	110/75	27	104	12.23	24	.5096	2.9	18.05	1.0	2.85		
0-2	8	100/75	27	124	14.58	24	.6075	2.9	18.	.92	2.95		
0-3	9	102/75	28	148	17.40	24	.7250	2.65	18.6	1.17	2.22		
0-4													
Net O_2 Debt	.6523												

WORK CAPACITY TEST

Ht. of Step at Start: 4"
Name: D. P.
Age: 11 Height: 4'6" Weight: 67 lbs.

Abdominal 4.5 Subscapular 5
Temp: 24 Triceps Measure: 6
Bar Pr: 739 Vital Capacity: 130
RGS: 35 LGS: 40
SA 1.14 C.F. .874
Type Test: Step Sex: M X F

min.	Bag Nr.	Syst/ Diast	Pulse	Vent Kym.	Vent Corr.	Vent Rate	Tidal V/L	CO_2	O_2	RQ	True O_2	EMR SMR	
Rest	1	98/68	20	53	10.48	33	.0032	2.71	19.3	1.59	1.7	27.58	
0-1	2	104/68	34										
1-2	3	110/70	38	132	15.37	28	.5489	2.5	19.3	1.60	1.55	62.68 / 27.58	2.72
2-3	4	112/70	39										
3-4		118/70	41	164	19.09	32	.5966	3.0	18.6	1.38	2.15	108.04 / 27.58	3.916
4-5	5	122/70	43										
5-6	6	122/70	43	156	18.16	36	.5044	3.45	18.0	1.22	2.79	133.34 / 27.58	4.834
6-7	7	120/70	48	240	27.94	40	.6985	3.40	18.2	1.31	2.55	187.47 / 27.58	6.797
7-8	8	118/70	44	280	32.60	40	.8150	3.32	18.2	1.28	2.55	218.74 / 27.58	7.931
8-9													
9-10													
10-11													
11-12													
12-13													
13-14													
14-15													
15-16													
16-17													
17-18													
Rec. 0-1	9	128/68	29	72	8.382	20	.4191	2.5	19.0	1.4	1.80		
0-2	10	110/68	27	68	7.916	20	.3958	2.3	19.4	1.45	1.60		
0-3	11	104/68	22	52	6.0536	20	.3027						
0-4													
Net O_2 Debt	.0677												

2nd Test

WORK CAPACITY TEST

Ht. of Step at Start: 4"

Name: D. P.

Abdominal____ Subscapular____
Temp: ____ Triceps Measure: ____
Bar Pr: ____ Vital Capacity: ____
RGS: ____ LGS: ____

Age: ____ Height: ____ Weight: ____ Type Test: ____ Sex: M___ F___

min.	Bag Nr.	Syst/ Diast	Pulse	Vent Kym.	Vent Corr.	Vent Rate	Tidal V/L	CO_2	O_2	RQ	True O_2	EMR SMR
Rest		97/67	19									
0-1		105/68	35									
1-2		109/70	38									
2-3		113/70	39									
3-4		119/70	42									
4-5		123/70	42									
5-6		122/70	43									
6-7		119/70	47									
7-8		117/70	48									
8-9												
9-10												
10-11												
11-12												
12-13												
13-14												
14-15												
15-16												
16-17												
17-18												
Rec. 0-1		115/69										
0-2		113/67										
0-3		108/66										
0-4												
Net O_2 Debt												

WORK CAPACITY TEST

Abdominal 3.5 Subscapular 5
Ht. of Step at Start: 4" Temp: 23 Triceps Measure: 7
Bar Pr: 739 Vital Capacity: 100
Name: M. J. RGS: 32 LGS: 32
CF .880 SA 1.21
Age: 11 Height: 52½" Weight: 56 lbs. Type Test: Step Sex: M F

min.	Bag Nr.	Syst/ Diast	Pulse	Vent Kym.	Vent Corr.	Vent Rate	Tidal V/L	CO_2	O_2	RQ	True O_2	EMR SMR	
Rest		90/55	21	131		36		2.2	18.6	.92	2.34	92.68	
0-1		100/50	30	96									
1-2		100/50	29	100									
2-3	1	105/50	29	116	13.59	28	.4856	1.65	18.5	.65	2.56	92.68	1.00
3-4		110/50	30	172									
4-5	2	105/50	30	160	18.75	36	.5209	2.3	17.5	.6	3.74	173.90 / 82.68	1.876
5-6		105/55	33	192									
6-7	5	105/55	36	200	23.44	36	.6512	2.65	17.1	.62	4.15	230.925 / 92.68	2.49
7-8	6	105/55	36	192	22.50	44	.5114	2.75	17.	.64	4.24	236.578 / 92.68	2.55
8-9	7	100/55	36	272	31.88	56	.5693	2.55	17.1	.60	4.19	331.1899 / 92.68	3.57
9-10													
10-11													
11-12													
12-13													
13-14													
14-15													
15-16													
16-17													
17-18													
Rec. 0-1		90/55	24	108	28	12.65		2.15	17.5	.55	3.76		
0-2		85/50	21	96	24	11.25		1.85	17.8	.55	3.45		
0-3		85/55	21	108	32	12.65		1.6	19.	.75	2.05		
0-4													
Net O_2 Debt													

WORK CAPACITY TEST

Ht. of Step at Start: 4"

Name: G. H.

Age: 11 Height: 4' 7" Weight: 83½

Abdominal 7 Subscapular 5

Temp: 26 Triceps Measure: 5

Bar Pr: 736 Vital Capacity: 126

RHS: 45 WHS: 35

S.A. 1.22 C.F. 861

Type Test: Step Sex: M X F

min.	Bag Nr.	Syst/ Diast	Pulse	Vent Kym.	Vent Corr.	Vent Rate	Tidal V/L	CO_2	O_2	RQ	True O_2	EMR SMR	
Rest		108/68	108	55	.1072	20	.0054	2.05	19.2	1.46	1.70		
0-1		110/65	31										
1-2		115/65	34										
2-3	1	120/65	35	136	15.60	28	.5571	2.1	19.45	1.35	1.60	61.377 / 26.3606	2.32
3-4		120/65	36										
4-5	2	120/65	40	164	21.84	28	.7800	2.6	18.2	.93	2.75	127.13 / 26.36	4.83
5-6		125/65	39										
6-7	4	125/65	53	100	13.32	36	.3700	3.05	17.45	.83	3.60	101.53 / 26.36	3.85
7-8	5	110/65	42	272	31.19	52	.5998	3.5	17.2	.91	3.80	287.61 / 26.36	10.91
8-9	6	115/65	43	256		48		3.45	17.25	.91	3.75	127.68 / 26.36	4.82
9-10													
10-11													
11-12													
12-13													
13-14													
14-15													
15-16													
16-17													
17-18													
Rec. 0-1	7	110/75	33	92	10.54	24	.4392	2.35	18.5	.97	2.40		
0-2	8	105/70	28	76	8.71	24	.3629	1.85	19.	.95	1.95		
0-3	9	105/70	31	72	8.26	24	.3442	1.85	19.	.91	2.		
0-4													
Net O_2 Debt	.2663												

WORK CAPACITY TEST

Ht. of Step at Start: 4 "

Name: J.D.

Age: 11 Height: 4' 8" Weight: 86

Abdominal 4 Subscapular 6
Temp: 17 Triceps Measure: 11
Bar Pr: 74.7 Vital Capacity: 130
RGS: 35 LGS: 23
S.A. 1.24 C.F. .915
Type Test: Step Sex: M X F ___

min.	Bag Nr.	Syst/ Diast	Pulse	Vent Kym.	Vent Corr.	Vent Rate	Tidal V/L	CO_2	O_2	RQ	True O_2	EMR SMR	
Rest		80/55	37	126		30		2.1	20.1	1.15	.85	31.55	
0-1		115/65	28			36		1.25	20.8	.85	.70		
1-2	1	120/65	30	144	17.54	44	.3986	1.8	21.2	.95	.87	36.90 / 31.55	1.17
2-3		130/65	33			44		2.25	19.4	1.35	.70		
3-4	2	130/65	33	196	23.89	36	.6636	2.35	19.1	1.34	.75	43.35 / 31.55	1.37
4-5		135/ 60	36			40		2.3	19.1	1.35	.71		
5-6	3	135/60	40	308	37.54	24.2	1.5642	1.7	19.4	.97	.85	77.20 / 31.55	2.29
6-7		135/65	38			36		2.7	18.8	1.4	.95		
7-8	4	135/65	41	256	31.20	40	.7800	2.65	18.4	1.6	2.49	187.94 / 31.55	5.94
8-9	5	140/65	48	276	33.64	40	.8410	2.6	18.4	1.05	2.50	203.47 / 31.55	6.45
9-10	6	140/65	48	288	35.10	32	1.0969	2.59	18.4	1.03	2.50	212.30 / 31.55	6.73
10-11													
11-12													
12-13													
13-14													
14-15													
15-16													
16-17													
17-18													
Rec. 0-1													
0-2													
0-3													
0-4													
Net O_2 Debt													

WORK CAPACITY TEST

Abdominal 5 Subscapular 5
Temp: 22 Triceps Measure: 10
Bar Pr: 744 Vital Capacity: 95
RGS: 35 LGS: 28

Ht. of Step at Start: 4"

Name: P. J.

S.A. 1.08 C.F. .890

Age: 11 Height: 4' 5½" Weight: 56 Type Test: Step Sex: M X F

min.	Bag Nr.	Syst/ Diast	Pulse	Vent Kym.	Vent Corr.	Vent Rate	Tidal V/L	CO_2	O_2	RQ	True O_2	EMR / SMR	
Rest		100/64	18	66		23		2.65	17.3	.67	3.90		
0-1		106/66	32										
1-2		108/70	32										
2-3	1	116/70	34	148	17.54	32	.5481	2.6	17.2	.64	4.01	195.39 / 84.75	2.30
3-4		120/70	34										
4-5	2	122/70	36	124	14.70	32	.4594	2.51	16.19	.44	5.40	220.50 / 84.75	2.60
5-6		124/70	37										
6-7	3	127/70	41	156	18.49	36	.5136	2.8	16.9	.63	4.35	223.42 / 84.75	2.6
7-8		128/69	44										
8-9	4	132/70	46	176	20.86	40	.5215	3.	17.	.71	4.16	241.06 / 84.75	2.8
9-10	5	128/70	47	178	21.10	42	.5024	3.08	16.72	.87	4.32	253.19 / 84.75	2.98
10-11													
11-12													
12-13													
13-14													
14-15													
15-16													
16-17													
17-18													
Rec. 0-1	6	120/68	34	164	19.44	32	.6075	2.75	17.8	.85	3.21		
0-2	7	116/68	28	104	12.33	28	.4404	2.48	17.4	.65	3.80		
0-3		100/67	28	128	15.17	24	.6321						
0-4													
Net O_2 Debt	.4823												

WORK CAPACITY TEST

Ht. of Step at Start: 4"

Name: J.W.

Age: 11 Height: 5'1" Weight: 56.8 125

Abdominal 25 Subscapular 20
Temp: 24 Triceps Measure: 22
Bar Pr: 742 Vital Capacity: 140
RGS: 55 LGS: 55
SA 1.52 CF. .879
Type Test: Step Sex: M X F

min.	Bag Nr.	Syst/ Diast	Pulse	Vent Kym.	Vent Corr.	Vent Rate	Tidal V/L	CO_2	O_2	RQ	True O_2	EMR SMR	
Rest		108/64	21	111	.4885	24	.0204	2.71	17.4	.7	3.76		
0-1		108/66	24										
1-2	1	110/68	31	180	21.08	32	.6588	3.1	16.45	.63	4.85	201.79 / 96.41	[illegible].093
2-3		130/70	33										
3-4	2	128/70	38	228	26.70	32	.8344	3.25	16	.6	5.37	282.99 / 96.41	[illegible].935
4-5		128/70	40										
5-6	3	130/70	42	256	29.97	40	.7492	3.5	15.85	.62	5.51	325.91 / 96.41	[illegible].380
6-7	4	132/70	46	276	32.31	44	.7343	3.5	16	.65	5.32	339.26 / 96.41	3.5189
7-8	5	128/70	46	316	37.00	56	.6607	3.25	16.6	.69	4.62	337.38 / 96.41	3.4994
8-9													
9-10													
10-11													
11-12													
12-13													
13-14													
14-15													
15-16													
16-17													
17-18													
Rec. 0-1	6	120/68	31	212	24.82	36	.6894	2.65	17.4	.7	3.76		
0-2	7	120/68	29	216	25.29	36	.7025						
0-3	8	110/68	25	128	14.99	24	.6246	2.2	17.65	.61	3.55		
0-4		12/1452 / 822											
Net O_2 Debt		.8788											

WORK CAPACITY TEST

Abdominal 8 Subscapular 5
Ht. of Step at Start: 4" Temp: 23 Triceps Measure: 8
Bar Pr: 738 Vital Capacity: 136
Name: E. R. RGS: 40 LGS: 41
S.A. 1.20 C.F. .877
Age: 11 Height: 4' 7" Weight: 72 Type Test: Step Sex: M x F

min.	Bag Nr.	Syst/ Diast	Pulse	Vent Kym.	Vent Corr.	Vent Rate	Tidal V/L	CO_2	O_2	RQ	True O_2	EMR / SMR	
Rest		90/65	20	68	.2510	17	.0148	2.7	17.85	.85	3.16		
0-1		90/70	30										
1-2		100/70	33										
2-3	1	100/70	33	156	18.22	28	.6507	2.3	18.4	.9	2.56	116.60 / 62.75	1.86
3-4		100/70	33										
4-5	2	100/70	36	152	20.25	24	.8438	2.6	17.6	.74	3.50	153.30 / 62.75	2.44
5-6		105/70	40										
6-7	3	105/70	40	200	23.36	20	1.1680	2.55	17.4	.66	3.80	221.925 / 62.75	3.54
7-8	4	105/70	42	260	30.37	28	1.0846	2.69	17.4	.71	3.75	284.70 / 62.75	4.54
8-9	5	100/ 75	45	264	30.84	40	.7710	3.1	17.5	.88	3.50	269.85 / 62.75	4.30
9-10													
10-11													
11-12													
12-13													
13-14													
14-15													
15-16													
16-17													
17-18													
Rec. 0-1	6	110/65	28	116	3.27	28	.1168	2.78	17.9	.9	3.08		
0-2	7	96/65	25	112	3.27	28	.1168	2.4	18.6	1.05	2.30		
0-3	9	90/65	25	116	2.81	24	.1171	1.95	19.	1.0	1.95		
0-4													
Net O_2 Debt													

WORK CAPACITY TEST

Ht. of Step at Start: 4"

Name: B. H.

Age: 11 Height: 4'7" Weight: 73 (33.2)

Abdominal 6 Subscapular 7
Temp: 24 Triceps Measure: 11
Bar Pr: 739 Vital Capacity: 125
RGS: 46 LGS: 45
SA- 1.18 CF .874
Type Test: Step Sex: M X F

min.	Bag Nr.	Syst/ Diast	Pulse	Vent Kym.	Vent Corr.	Vent Rate	Tidal V/L	CO_2	O_2	RQ	True O_2	EMR SMR	
Rest		100/68	96	140		38		2.2	20.5	2.2	.70		
0-1		110/70	32	152	17.97	28		1.80	10.9	1.35	1.30	59.36 / 28.98	2.048
1-2		110/70	33	172	20.02	36		2.7	18.9	1.44	1.86	94.67 / 28.98	3.266
2-3		110/70	35	228	26.54	44		2.8	17.6	.81	3.45	232.80 / 28.98	8.033
3-4		115/65	39							.91	3.27	/ 28.98	
4-5		120/70	43	240	27.94	48		3.0	17.7	.84	3.44	244.34 / 28.98	8.431
5-6		120/70	44										
6-7		125/70	45	260	30.27	56		2.92	17.6	.83	3.45	265.47 / 28.98	9.160
7-8		120/70	46	292	33.99	52		3.12	17.6	.91	3.34	288.63 / 28.98	
8-9		120/70	50	292	33.99	52		3.12	16.6	.91	3.39	288.63 / 28.98	9.959
9-10													
10-11													
11-12													
12-13													
13-14													
14-15													
15-16													
16-17													
17-18													
Rec. 0-1		110/70	31	192		28		2.8	18.2	1.02	2.70		
0-2		100/70	26	56		24		1.41	19.4	.85	1.85		
0-3		90/70	25	56		24		1.62	19.8	.9	1.85		
0-4													
Net O_2 Debt													

WORK CAPACITY TEST

Abdominal 13 Subscapular 11

Ht. of Step at Start: 4" Temp: 21 Triceps Measure: 10

Bar Pr: 736 Vital Capacity: 164

Name: S. B. RGS: 47 LGS: 45

47.3 SA- 1.42 CF- .883

Age: 11 Height: 5'1" Weight: 104 Type Test: Step Sex: M X F

min.	Bag Nr.	Syst/ Diast	Pulse	Vent Kym.	Vent Corr.	Vent Rate	Tidal V/L	CO_2	O_2	RQ	True O_2	EMR SMR	
Rest		104/ /69	24	84	.709	17	.0100	3.61	18.8	2.1	1.73	36.11	
0-1		108/ /75	27										
1-2		110/ /75	31										
2-3	1	110/ /70	34	168	19.76	24	.8233	3.56	18.6	1.77	2.00	83.49 / 36.11	2.31
3-4		115/ /70	35										
4-5	2	120/ /70	36					3.28	17.7	1.01	3.21	/ 36.11	
5-6		120/ /70	38										
6-7	4	120/ /70	42	284	33.40	36.	.9278	3.3	17.64	.99	3.30	232.86 / 36.11	6.45
7-8	5	110/ /70	44	284	33.40	32	1.0438	3.55	17.4	1.0	3.56	249.80 / 36.11	6.92
8-9	6	110/ /70	46	292	34.33	40	.8582	3.6	17.2	.95	3.76	272.70 / 36.11	7.55
9-10													
10-11													
11-12													
12-13													
13-14													
14-15													
15-16													
16-17													
17-18													
Rec. 0-1	7	110/ /75	27	104	12.23	24	.5096	2.9	18.05	1.0	2.85		
0-2	8	100/ /75	27	124	14.58	24	.6075	2.9	18	.92	2.95		
0-3	9	102/ /75	28	148	17.40	24	.7250	2.65	18.6	1.17	2.22		
0-4	13/	1439 / 934	110.69 / 71.85										
Net O_2 Debt		.6523											

RECORDING FORM
WORK CAPACITY TEST

Ht. of Step at Start: 4"

Name: J. I.

Age: 11½ Height: 4'6" Weight: 40.5 89

Abdominal 9 Subscapular 7
Temp: Triceps Measure: 7
Bar Pr: Vital Capacity: 126
RGS: 36 LGS: 40
SA- 1.24 Cf- .875
Type Test: Sex: M X F

min.	Bag Nr.	Syst/ Diast	Pulse	Vent Kym.	Vent Corr.	Vent Rate	Tidal V/L	CO_2	O_2	RQ	True O_2	EMR / SMR	
Rest		92/68	18	126	.1174	24	.0049	2.4	19.4	1.5	1.59		
0-1		90/65	27										
1-2		90/60	30										
2-3	1	95/65	32	144	16.78	32	.5244	2.6	18.4	1.65	1.55	24.36 / 28.40	.8577
3-4		100/70	33										
4-5	2	100/65	33	196	22.85	40	.5712	2.9	18.6	1.31	2.18	82.94 / 28.40	2.90
5-6		100/70	34										
6-7	4	100/65	39	308	35.90	52	.6904	3.2	18.4	1.35	2.34	134.61 / 28.40	4.74
7-8		95/65	41										
8-9	5	100/65	43	256	29.84	52	.5738	3.3	18.6	1.58	2.06	86.64 / 28.40	3.05
9-10	6	105/65	44	276	36.76	52		3.15	18.7	1.6	1.97	70.02 / 28.40	2.46
10-11		105/65	49	288	33.56	52	.6453	3.2	18.5	1.42	2.22	105.53 / 28.40	3.72
11-12													
12-13													
13-14													
14-15													
15-16													
16-17													
17-18													
Rec. 0-1	9	95/60	26	184	21.45	52	.4125	2.9	18.9	1.58	1.80		
0-2	10	100/60	25	164	19.11	44	.4343	2.5	19.3	1.55	1.60		
0-3	11	95/60	24										
0-4	15/	1462 / 968	97.47 / 64.53										
Net O_2 Debt		.0324											

WORK CAPACITY TEST

Ht. of Step at Start: 4"

Name: J. I.

Age: 11½ Height: 4' 6" Weight: 89

Abdominal 9 Subscapular 7
Temp: Triceps Measure: 7
Bar Pr: Vital Capacity: 126
RGS: 36 LGS: 40
S.A. 1.24 C.F. .875
Type Test: Step Sex: MX F

min.	Bag. Nr.	Syst/ Diast	Pulse	Vent Kym.	Vent Corr.	Vent Rate	Tidal V/L	CO_2	O_2	RQ	True O_2	EMR SMR	
Rest		92/68	18	126	.1174	24	.0049	2.4	19.4	1.5	1.59		
0-1		90/65	27										
1-2		90/60	30										
2-3	1	95/65	32	144	16.78	32	.5244	2.6	19.4	1.65	1.55	24.36 / 28.40	.8577
3-4		100/70	33										
4-5	2	100/65	33	196	22.85	40	.5712	2.9	18.6	1.31	2.18	82.94 / 28.40	2.90
5-6		100/70	34										
6-7	4	100/65	39	308	35.90	52	.6904	3.2	18.4	1.35	2.34	134.61 / 28.40	4.74
7-8		95/65	41										
8-9	5	100/65	43	256	29.84	52	.5738	3.3	18.6	1.58	2.06	86.64 / 28.40	3.05
9-10	6	105/65	44	276	36.76	52		3.15	18.7	1.6	1.97	70.02 / 28.40	2.46
10-11		105/65	49	288	33.56	52	.6453	3.2	18.5	1.42	2.22	105.53 / 28.40	3.72
11-12													
12-13													
13-14													
14-15													
15-16													
16-17													
17-18													
Rec. 0-1	9	95/60	26	184	21.45	52	.4125	2.9	18.9	1.58	1.80		
0-2	10	100/60	25	164	19.11	44	.4343	2.5	19.3	1.55	1.60		
0-3	11	95/60	24										
0-4													
Net O_2 Debt	.0324												

WORK CAPACITY TEST

Ht. of Step at Start: 4"

Name: A. P.

Abdominal 5 | Subscapular 6
Temp: 24 | Triceps Measure: 4
Bar Pr: 739 | Vital Capacity: 192
RGS: 57 | LGS: 60
SA 1.39 | C.F. .874

Age: 12 Height: 4'3" Weight: 98½ lbs. Type Test: Step Sex: M X F___

min.	Bag Nr.	Syst/ Diast	Pulse	Vent Kym.	Vent Corr.	Vent Rate	Tidal V/L	CO_2	O_2	RQ	True O_2	EMR SMR	
Rest		114/64	26	48	10.61	18.9	.0056	3.0	18.8	1.59	1.90		
0-1	1	108/68	32	220	25.61	48	.5335	2.8	18.5	1.2	2.30	127.73 / 22.90	5.57
1-2		124/68	34										
2-3	2	128/70	35	252	29.33	48	.6110	3.05	18.2	1.14	2.65	167.78 / 22.90	7.326
3-4		129/70	37										
4-5	3	136/70	39	296	34.46	48	.7179	3.12	18.4	1.32	2.36	175.51 / 22.90	7.66
5-6		137/70	40										
6-7	4	140/70	41	308	35.86		.6404	3.2	18.2	1.22	2.60	201.22 / 22.90	8.78
7-8	5	140/71	41	340	39.58		.7068	3.3	18.2	1.27	2.56	218.68 / 22.90	9.54
8-9	6	134/70	42	324	37.72	44	.8573	3.72	18.0	1.36	2.72	221.42 / 22.90	9.66
9-10	7	134/70	44	356	41.44	48	.8633	3.3	18.1	1.21	2.70	241.51 / 22.90	10.54
10-11	8	134/68	47	376	43.77	56	.7816	3.3	18.1	1.21	2.70	255.06 / 22.90	11.137
11-12													
12-13													
13-14													
14-15													
15-16													
16-17													
17-18													
Rec. 0-1	9	136/70	30	160	18.63	32	.5822	2.85	18.6	1.28	2.19		
0-2	10	132/68	29					3.84	19.4				
0-3	11	124/68	28	96	11.18	20	.5590	2.5	19.8	1.8	1.20		
0-4													
Net O_2 Debt	.3296												

First Test

WORK CAPACITY TEST

Ht. of Step at Start: 4"

Name: B. C.

Age: 12 Height: 60¼" Weight: 89

Abdominal ______ Subscapular ______
Temp: 23° Triceps Measure: ______
Bar Pr: 738 Vital Capacity: ______
RBS: ______ LBS: ______
S.A. 131 C.F. .877
Type Test: Step Sex: M X F ___

min.	Bag Nr.	Syst/ Diast	Pulse	Vent Kym.	Vent Corr.	Vent Rate	Tidal V/L	CO_2	O_2	RQ	True O_2	EMR SMR	
Rest		126/68	26	80	.1552	20	.0078	2.59	19.2	1.57	1.66	35.54	
0-1		140/68	37										
1-2		140/68	37	172	20.09	32	.6278	2.85	17.9	.92	3.06	140.79 / 35.54	3.96
2-3		142/69	38										
3-4		142/70	38	184	21.50	28	.7678	3.15	17.3	.825	3.77	185.63 / 35.54	5.22
4-5		144/70	39										
5-6		138/70	39	200	23.36	36	.6489	3.3	17.	.80	4.10	219.32 / 35.54	6.17
6-7		138/70	40										
7-8		137/70	42	256	29.91	40	.7478	3.5	17.	.85	4.05	277.42 / 35.54	7.81
8-9		134/70	44										
9-10		132/70	47	260	30.37	40	.7592	3.68	16.	.69	5.29	367.92 / 35.54	10.35
10-11													
11-12													
12-13													
13-14													
14-15													
15-16													
16-17													
17-18													
Rec. 0-1		130/68	29	124	14.49	31	.4674	3.1	17.1	.76	4.02		
0-2		118/68	27	108	12.61	27	.4670	2.75	17.7	.8	3.36		
0-3		114/67	25	96	11.22	24	.4675	2.08	17.9	.63	3.25		
0-4													
Net O_2 Debt	.9052												

Second Test

WORK CAPACITY TEST

Abdominal________ Subscapular________

Temp:________ Triceps Measure:________

Bar Pr:________ Vital Capacity:________

RGS:________ LGS:________

Ht. of Step at Start: 4"

Name: B. C.

Age: 12 Height:________ Weight:________ Type Test:________ Sex: M__ F__

min.	Bag Nr.	Syst/ Diast	Pulse	Vent Kym.	Vent Corr.	Vent Rate	Tidal V/L	CO_2	O_2	RQ	True O_2	EMR SMR
Rest		126/68	26									
0-1		140/68	37									
1-2		140/68	37									
2-3		142/69	38									
3-4		142/70	38									
4-5		144/70	39									
5-6		138/70	39									
6-7		138/70	40									
7-8		134/70	42									
8-9		134/70	44									
9-10		132/70	47									
10-11												
11-12												
12-13												
13-14												
14-15												
15-16												
16-17												
17-18												
Rec. 0-1		130/68	29									
0-2		118/68	27									
0-3		114/67	25									
0-4												
Net O_2 Debt												

WORK CAPACITY TEST

Abdominal: 6 | Subscapular: 7
Temp: 24 | Triceps Measure: 13
Bar Pr: 740 | Vital Capacity: 160
RGS: 52 | LGS: 50
SA 1.32 | C.F. .876

Ht. of Step at Start: 4"

Name: P. H.

Age: 12 Height: 4' 9" Weight: 97 Type Test: Step Sex: M X F ___

min.	Bag Nr.	Syst/ Diast	Pulse	Vent Kym.	Vent Corr.	Vent Rate	Tidal V/L	CO_2	O_2	RQ	True O_2	EMR / SMR	
Rest		100/70	27	118	33.86	16	.0212	2.7	18.4	1.07	2.46	76.95	
0-1		100/70	32										
1-2		100/70	35										
2-3	1	110/75	39	168	19.60	28	.7000	2.61	17.7	.76	3.39	127.886 / 76.95	1.66
3-4		110/75	40										
4-5	2	115/75	40	236	27.54	28	.9836	2.75	17.6	.78	3.46	216.57 / 76.95	2.81
5-6	5	120/75	44	280	32.67	28	1.1668	3.21	17.0	.77	3.14	307.39 / 76.95	3.99
6-7	6	125/75	46	284	33.13	40	.8282	3.35	16.9	.76	4.25	320.00 / 76.95	4.16
7-8	7	120/70	46	288	33.60	40	.8400	3.3	16.9	.77	4.22	322.25 / 76.95	4.19
8-9													
9-10													
10-11													
11-12													
12-13													
13-14													
14-15													
15-16													
16-17													
17-18													
Rec. 0-1	8	120/75	33	140	16.34	28	.5836	1.75	18.52	.68	2.55		
0-2	9	110/75	30	140	7.46	16	.4662	2.65	17.6	.75	3.50		
0-3	10	100/75	29	104	12.13	16	.7581	2.12	18.5	.85	2.49		
0-4													
Net O_2 Debt	.6412												

WORK CAPACITY TEST

Ht. of Step at Start: 4"

Name: B. T.

Age: 12 Height: 58½" Weight: 88

Abdominal 6 Subscapular 6
Temp: 22 Triceps Measure: 12
Bar Pr: 744 Vital Capacity: 156
RGS: 54 LGS: 45
S.A. 1.26 C.F. .890
Type Test: ______ Sex: M ___ F ___

min.	Bag Nr.	Syst/ Diast	Pulse	Vent Kym.	Vent Corr.	Vent Rate	Tidal V/L	CO_2	O_2	RQ	True O_2	EMR SMR	
Rest		90/50	17	50		12		2	18	.63	3.15		
0-1		100/50	27										
1-2	1	100/55	32	152	18.02	28	.6436	2.1	18	.65	3.15	135.14 / 44.45	3.04
2-3		100/60	31										
3-4	2	105/60	34	144	17.07	18	.9483	3	17	.71	4.17	169.48 / 44.45	3.81
4-5		110/60	34										
5-6	3	115/60	36	188	22.28	24	.9283	3.2	17	.77	4.11	218.02 / 44.45	4.90
6-7		115/60	38										
7-8	4	120/60	42	260	30.82	30	1.0273						
8-9		120/60	42										
9-10	5	120/55	48	268	31.77	32	.9928	3.3	16	.61	5.36	405.45 / 44.45	9.12
10-11													
11-12													
12-13													
13-14													
14-15													
15-16													
16-17													
17-18													
Rec. 0-1													
0-2													
0-3													
0-4													
Net O_2 Debt	1.071												

First Test

WORK CAPACITY TEST

Ht. of Step at Start: 4 Inches

Name: R. M.

Age: 12 Height: ______ Weight: ______

Abdominal ______ Subscapular ______

Temp: 23 Triceps Measure: ______

Bar Pr: 738 Vital Capacity: ______

RGS: ______ LGS: ______

SA 1.43 C.F. .877

Type Test: ______ Sex: M ___ F ___

min.	Bag Nr.	Syst/ Diast	Pulse	Vent Kym.	Vent Corr.	Vent Rate	Tidal V/L	CO_2	O_2	RQ	True O_2	EMR / SMR	
Rest		108/67	18	90	.3289	22	.0150	2.7	17.9	.85	3.12		
0-1		136/70	29	172		44							
1-2	1	136/68	28	180	24.99	40	.6248	2.7	17.5	.74	3.62	188.73 / 69.00	2.74
2-3		142/69	30	212		48							
3-4	2	154/70	32	216	34.63	40	.8658	3.3	16.6	.71	4.61	295.78 / 69.00	4.29
4-5		158/70	34	260		44							
5-6	5	158/70	35	280	39.96	48	.8325	3.62	16.4	.75	4.79	353.10 / 69.00	5.13
6-7		159/70	38	300		52							
7-8		154/71	40	300	40.07	52	.7706	3.8	16.4	.79	4.79	396.78 / 69.00	5.75
8-9		154/70	43	340									
9-10		154/70	44	380	44.79	52	.8613	3.55	16.6	.77	4.55	427.53 / 69.00	6.20
10-11		150/70	45	468	53.98		1.0381	3.89	16.4	.82	4.70	532.26 / 69.00	7.71
11-12													
12-13													
13-14													
14-15													
15-16													
16-17													
17-18													
Rec. 0-1		152/65	29	216	25.46	40	.6365	3.25	17.1	.81	3.99		
0-2		138/66	23	112	13.20	28	.4714	2.9	17.5	.81	3.55		
0-3		134/68	23	108	12.74	28	.455	2.5	18	.82	3.01		
0-4													
Net O_2 Debt	.1928												

Second Test

WORK CAPACITY TEST

Ht. of Step at Start: 4"

Name: R. M.

Abdominal______ Subscapular______

Temp:______ Triceps Measure:______

Bar Pr:______ Vital Capacity:______

RGS:______ LGS:______

Age: 12 Height:______ Weight:______ Type Test:______ Sex: M__ F__

min.	Bag Nr.	Syst/ Diast	Pulse	Vent Kym.	Vent Corr.	Vent Rate	Tidal V/L	CO_2	O_2	RQ	True O_2	EMR SMR
Rest		106/68	19									
0-1		135/69	22									
1-2		135/69	28									
2-3		140/68	31									
3-4		148/70	31									
4-5		151/70	33									
5-6		153/70	36									
6-7		159/70	37									
7-8		160/70	40									
8-9		160/70	43									
9-10		158/70	45									
10-11		157/70	44									
11-12												
12-13												
13-14												
14-15												
15-16												
16-17												
17-18												
Rec. 0-1		155/68	38									
0-2		153/67	34									
0-3		148/64	25									
0-4												
Net O_2 Debt												

1st Test

WORK CAPACITY TEST

Ht. of Step at Start: 4"

Name: K. K.

Abdominal 12   Subscapular 12
Temp: 22   Triceps Measure: 12
Bar Pr: 736   Vital Capacity: 152
RGS: 49   LGS: 47

Age: 12   Height: 60"   Weight: 86   Type Test: Step   Sex: M X F

min.	Bag Nr.	Syst/ Diast	Pulse	Vent Kym.	Vent Corr.	Vent Rate	Tidal V/L	CO_2	O_2	RQ	True O_2	EMR SMR
Rest		108/64	24									
0-1		110/64	35									
1-2		110/68	36									
2-3	2	112/70	39									
3-4		114/70	43									
4-5	3	120/70	45									
5-6	4	120/70	45									
6-7	5	128/70	47									
7-8	6	122/70	48									
8-9	7	120/70	48									
9-10												
10-11												
11-12												
12-13												
13-14												
14-15												
15-16												
16-17												
17-18												
Rec. 0-1	8	114/68	33									
0-2	9	128/68	32									
0-3	10	114/69	29									
0-4												
Net O_2 Debt												

WORK CAPACITY TEST

Ht. of Step at Start: 4"

Name: K. E.

Age: 12 Height: 4' 7" Weight: 89 Type Test: Step Sex: M X F

Abdominal 12 Subscapular 12
Temp: 24 Triceps Measure: 12
Bar Pr: 742 Vital Capacity: 152
RGS: 49 LGS: 47
SA 1.24 C.F. .879

min.	Bag Nr.	Syst/ Diast	Pulse	Vent Kym.	Vent Corr.	Vent Rate	Tidal V/L	CO_2	O_2	RQ	True O_2	EMR SMR	
Rest		108/64	24	48		18		3.	16.85	.68	4.36		
0-1		110/64	35	132		32							
1-2		110/68	36	132		28							
2-3	2	112/70	39	168	19.67	32	.6147	2.65	17.2	.65	4.	190.355 / 59.25	3.21
3-4		114/70	43										
4-5	3	120/70	45	196	22.94	40	.5735	3.25	16.4	.66	4.87	270.29 / 59.25	4.56
5-6	4	120/70	45	216	25.29	40	.6322	3.39	16.2	.66	5.10	297.97 / 59.25	
6-7	5	128/70	47	212	24.82	48	.5171	3.61	16.05	.77	4.65	292.427 / 59.25	5.03
7-8	6	122/70	48	220	25.75	36	.7153	3.7	15.85	.77	5.46	303.39 / 59.25	5.12
8-9	7	120/70	48	248	29.03	32	.9072	3.61	15.85	.65	5.49	342.05 / 59.25	5.77
9-10													
10-11													
11-12													
12-13													
13-14													
14-15													
15-16													
16-17													
17-18													
Rec. 0-1	8	144/68	33	104	12.17	24	.5071	3.25	16.2	.63	5.14		
0-2	9	128/68	32	64	7.489	25	.2996	2.71	16.6	.56	4.76		
0-3	10	114/69	29	72	8.43	20	.4215	2.71	16.8	.59	4.50		
0-4													
Net O_2 Debt	.6266												

WORK CAPACITY TEST

Ht. of Step at Start: 4"

Name: K. B.

Age: 12 Height: 4'11" Weight: 118 (53.6)

Abdominal 33 Subscapular 22

Temp: 23° Triceps Measure: 22

Bar Pr: 738 Vital Capacity: 150

RGS: 45 lbs LGS: 45 lbs

SA-1.46 CF-887

Type Test: ____ Sex: M x F ____

min.	Bag Nr.	Syst/ Diast	Pulse	Vent Kym.	Vent Corr.	Vent Rate	Tidal V/L	CO_2	O_2	RQ	True O_2	EMR SMR	
Rest		125/68	25	56	.1373	23	.0060	2.1	18.8	1.0	2.10	28.21	
0-1		140/40	35										
1-2		144/70	37										
2-3	1	144/70	38	112	13.08	36	.3633	2.2	18.4	.85	2.59	69.61/28.21	2.47
3-4	2	144/70	41	132	15.42	40	.3855	2.7	17.8	.82	3.25	118.81/28.21	4.21
4-5	3	148/70	43	140	16.36	40	.4090	3	17.45	.83	3.60	121.03/28.21	4.29
5-6	4	148/70	45	128	14.95	32	.4672	3.2	17.4	.87	3.62	111.20/28.21	3.94
6-7	5	146/70	47	172	20.09	40	.5022	3.3	17.05	.81	4.03	166.36/28.21	5.90
7-8													
8-9													
9-10													
10-11													
11-12													
12-13													
13-14													
14-15													
15-16													
16-17													
17-18													
Rec. 0-1	6	162/70	31	88	10.27	28	.3668	3.1	17.4	.84	3.65		
0-2	7	144/68	29	85	9.93	26	.3819	2.95	17.65	.87	3.36		
0-3	9	134/68	25	80	9.35	28	.3339	2.4	18.2	.85	2.79		
0-4	10/	1417/664	141.7/66.4										
Net O_2 Debt		.8319											

WORK CAPACITY TEST

Abdominal 5 Subscapular 5

Ht. of Step at Start: 4" Temp: 23 Triceps Measure: 7

Bar Pr: 740 Vital Capacity: 144

Name: D. S. RGS: 40 LGS: 50

CF .881

Age: 12 Height: 59" 4'9" Weight: 74½ Type Test: Step Sex: M X F ___

min.	Bag Nr.	Syst/ Diast	Pulse	Vent Kym.	Vent Corr.	Vent Rate	Tidal V/L	CO_2	O_2	RQ	True O_2	EMR SMR	
Rest		84/64	19	87	.2400	19	.0126	2.5	18.52	1.05	2.35	59.02	
0-1		85/55	29										
1-2		85/55	32										
2-3	1	85/50	32	140	16.42	28	.5864	2.3	18.5	.93	2.45	102.95 / 29.02	1.74
3-4		85/50	32										
4-5	2	85/50	34	144	16.90	21	.8048	2.61	17.1	.62	4.15	172.48 / 59.02	2.92
5-6		90/50	35										
6-7	5	90/50	37	180	21.13	21	1.0062	3.02	17.3	.79	3.77	195.89 / 59.02	3.32
7-8		100/50	39										
8-9	6	100/50	39	200	23.47	36	.6519	3.3	17.3	.87	3.71	214.11 / 59.02	3.63
9-10		100/55	42										
10-11	7	100/55	47	216	25.35	44	.5761	3.15	17.2	.8	3.85	240.00 / 59.02	4.07
11-12													
12-13													
13-14													
14-15													
15-16													
16-17													
17-18													
Rec. 0-1	8	105/55	26	148	17.36	24	.7233	3.0	17.4	.81	3.66		
0-2	9	100/55	23	84	9.86	20	.4930	2.5	17.8	.76	3.30		
0-3	10	90/50	24	96	11.27	20	.5635	2	18.52	.79	2.44		
0-4		15/1384 / 954	92.27 / 63.6										
Net O_2 Debt		1.3588											

WORK CAPACITY TEST

Ht. of Step at Start: 4"

Name: M.D.

Age: 13 Height: 4'11" Weight: 78" (35.5)

Abdominal 4 Subscapular 5
Temp: 22° C Triceps Measure: 6mm
Bar Pr: 744 Vital Capacity: 160
RGS: 45 LGS: 40
SA 1.27 CF-.892
Type Test: Step Sex: M X F

min.	Bag Nr.	Syst/ Diast	Pulse	Vent Kym.	Vent Corr.	Vent Rate	Tidal V/L	CO_2	O_2	RQ	True O_2	EMR / SMR	
Rest		108/72	25	73	.1648	24	.0069	2.28	19	1.15	1.90		
0-1		110/70	30	100		16							
1-2		114/70	32	122		20							
2-3	1	120/72	36	160	19.01	28	.6789	2.52	17.8	.72	3.31	148.63 / 38.93	3.82
3-4		125/72	37	140		32							
4-5	2	130/75	39	182	25.57	28	.9132	3.15	17.05	.89	3.50	169.56 / 38.93	4.36
5-6		130/80	42	220		40							
6-7	3	130/80	44	232	30.90	40	.7725	3.8	16.4	.80	4.74	308.57 / 38.93	7.93
7-8	5	135/85	46	248	29.46	40	.7365	3.75	16.4	.78	4.75	330.57 / 38.93	8.49
8-9	11	125/85	46	276	32.79	44	.7452	3.98	16.4	.84	4.69	363.26 / 38.93	9.33
9-10													
10-11													
11-12													
12-13													
13-14													
14-15													
15-16													
16-17													
17-18													
Rec. 0-1		130/80	32	96	11.41	28	.4075	3.6	16.6	.79	4.54		
0-2		120/80	29	84	9.98	28	.3564	3.31	16.85	.76	4.30		
0-3		115/75	29	56	6.65	24	.3771	2.15	17.7	.59	3.50		
0-4	13 / 13	1593 / 996	122.54 / 76.61										
Net O_2 Debt													

VITA

John Gilbert Bayless

Candidate for the Degree of

Doctor of Education

Thesis: FUNCTIONAL CAPACITY TEST FOR UPPER ELEMENTARY AGE BOYS

Major Field: Higher Education

Biographical:

Personal Data: Born at Ponca City, Oklahoma, January 7, 1935, the son of John and Faye Bayless.

Education: Attended elementary and junior high schools in Eureka, Kansas; graduated from Eureka High School in 1953; received the Bachelor of Science degree from Phillips University, Enid, Oklahoma, with a major in Secondary Education in May, 1957; received the Master of Education degree, with a major in Guidance and Counseling in June, 1961; completed requirements for the Doctor of Education degree May, 1966.

Professional experience: Appointed classroom teacher in the Blue Rapids Public Schools, Blue Rapids, Kansas, in 1959; taught in grades seven and eight; appointed to the position of Instructor on the faculty of Phillips University in 1960; appointed Assistant Professor in 1963; graduate assistant in Department of Health, Physical Education and Recreation, Oklahoma State University, 1964; returned to Phillips University as Associate Professor in 1965; appointed Assistant Professor of Health, Physical Education and Recreation, Oklahoma State University, 1966. Member of the American Association of Health, Physical Education and Recreation, Oklahoma Association of Health, Physical Education and Recreation, National Education Association and the Oklahoma Education Association.