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Thesis

A STUDY OF CERTAIN VARIABLES INFLUENCING PERFORMANCE SCORES ON THE HARVARD STEP TEST AND THE McCLOY ENDURANCE INDEX

Submitted by

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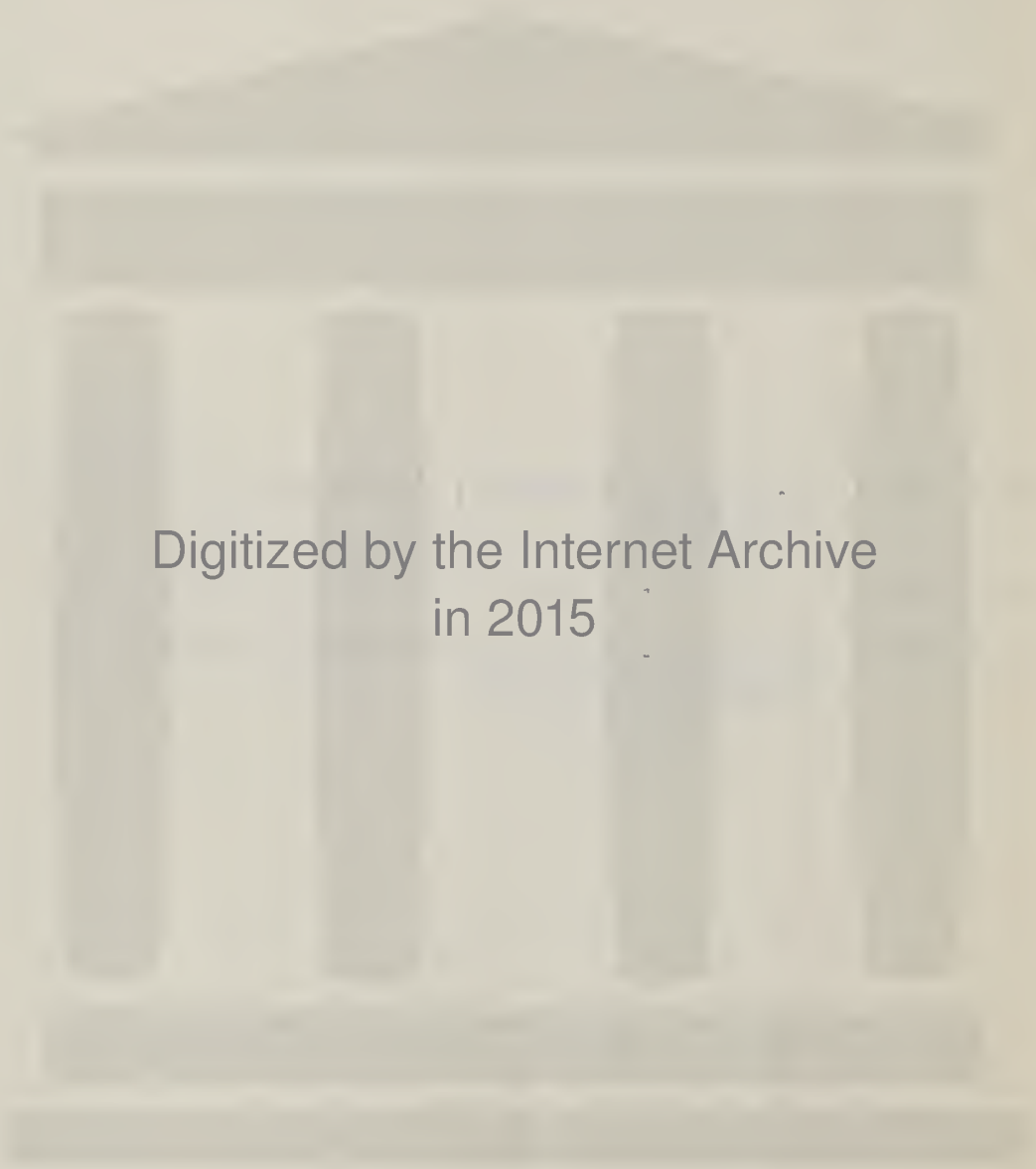

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CHAPTER I

INTRODUCTION

Statement of the problem. A study of certain variables influencing performance scores on the Harvard Step Test and the McCloy Endurance Ratio. The Harvard Step Test and the Brouha Test are used interchangeably as is the McCloy Endurance Ratio and McCloy Endurance Index.

Purpose of the problem. The purpose is to test the hypothesis that the Harvard Step Test and the McCloy Endurance Ratio should correlate moderately high as measures of endurance. If the correlation is not moderately high, then the influences of the other variables such as leg length, height, weight, physiological age, and body surface area must be indicated through an analysis and interpretation of the findings of the study.

Limitations of the problem. The study will be delimited to junior high and high school boys, who will be classified according to physiological age by Crampton's criteria for physiological age grouping.

Significance of the Problem. The research findings seem to indicate that, in general, the Brouha Test measures the heart response to exercise but that its validity and reliability are not markedly high in measuring endurance.

McCloy's endurance ratio although designated as an excellent criterion, has not been upheld as such by the research findings. The administering of these tests to the adolescent males in this study may be of further help in corroborating

evidence in the research findings, or of presenting new evidence which would give further insight into the difficulties that have been found to exist.

In relation to the hypothesis of the study it is presumed that the endurance ratio and performance scores on the step test should correlate moderately high. If not, then the influences of the other variables must be indicated through an analysis and interpretation of the findings of the study.

Review of pertinent literature. General physiological principles upon which the Harvard Step Test is based.

Cureton[1] states that, "although the pulse rate does not represent a complete test of circulatory-respiratory fitness, pulse rate tests make the easiest and simplest way to check circulatory-respiratory fitness."

Cureton[2] also states:

> many studies have gradually made it possible to interpret the pulse rate tests. The heart increases its output two ways: (1) by increasing the pulse rate and (2) by increasing the amount of contractile force per stroke. However, the pulse rate is not always directly proportional to the severity of the exercise because skill and other physiological adjustments are contributing variables. It is never quite certain whether the increased blood flow in response to a given exercise is caused by increased rate or by increased contractile force. This varies a good deal and makes it difficult to interpret pulse rate changes exactly.

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[1] T. K. Cureton, Physical Fitness Appraisal and Guidance, St. Louis: C. V. Mosby Co., 1947, p. 162.

[2] Ibid., p. 162.

Starling's[1] law of the heart implies that:

> the normal heart responds in blood flow in proportion to the diastolic filling and stretching of the muscular fibers in the ventricles, but the response is quite variable in the manner in which the circulation is increased.

Starling[2] accounts for the slower heart rate of trained athletes by stating that the output of blood per heart stroke is greater in the trained individual.

Cotton, Rapport, and Lewis[3] state, that "the rate of the pulse immediately after exercise is a gage of the degree of distress produced in the cardiovascular system. Therefore, the effect of exercises may be known by systematic studies showing the effect on the pulse rate."

Boothby[4] has presented some evidence that:

> pulse rate increases, up to a certain sub-maximal point, in proportion to the severity of exercise. Extremely violent speed or endurance exercises cannot be adequately measured by pulse rate alone because after the pulse rate reaches a virtual maximum and levels off, additional compensations occur, such as increased pulse pressure, additional contractile effort of the heart and development of an oxygen debt. In severe exercise the pulse rate may be a poor measure of the cost of an exercise.

In validating the use of heart rate as a cardiovascular

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[1] E. H. Starling, Principles of Human Physiology, Philadelphia; Lea and Febiger, 1926, Chap. 34 and 35.

[2] Ibid., Chap. 34 and 35.

[3] T. K. Cureton, op. cit., p. 163.

[4] W. P. Boothby, "A Determination of the Circulation Rate in Man at Rest and at Work," American Journal of Physiology, 37: pp. 383-417, 1915.

condition test Bowen[1] states:

> the pulse rate is due to (1) speed of exercise, (2) the effort in exercise, (3) the physiological condition of the subject, (4) to age, and (5) to posture and mental state of the subject. Better standardization of the technique and conditions under which pulse rate is observed, is urged.

There is ample evidence in the research findings to indicate that the more strenuous the exercise, the greater the reliability of the pulse rate.

Research Findings Related to the Brouha Step Test and McCloy's Endurance Ratio

The purpose of the Brouha Test was to fulfill a need for a simple test of physical fitness. It was based on general physiological principles, some of which have been mentioned in the previous pages.

Brouha and Heath's[2] work in the laboratory using a treadmill with an upgrade of 8.6%, and having the men run for five minutes showed a good relationship for all subjects (athletic and non-athletic) in deceleration of the pulse rate. In general, the fit men had a lower pulse rate. As other studies have also shown, initial pulse rate is too markedly affected by apprehension. Pulse rates taken a short time after an exer-

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[1]W. P. Bowen, "Changes in Heart Rate, Blood Pressure and Duration of Systole Resulting from Bicycling," American Physical Education Review, 8:8, 1903.

[2]L. Brouha and C. W. Heath, "Resting Pulse and Blood Pressure Values in Relation to Physical Fitness in Young Men," New England Journal of Medicine, 228: pp. 473-477, April 1943.

cise test, were lower, in comparison, to the initial pulse rate in men of ordinary ability. Therefore, for subjects of ordinary ability, the initial pulse rate does not seem to be reliable or valid as a single test.

This work led to the standardization of the Harvard Step Test, a five minute step test onto a 20-inch bench in 1942.[1]

> The most acceptable pulse rate was the recuperation pulse count from the maximum pulse rate immediately after the exercise. Because of the difficulty of taking the pulse rate immediately after the exercise, the pulse counts were recommended to be taken at 1:00-1:30, 2:00-2:30, and 3:00-3:30, and these three thirty second pulse counts summed. The total pulse count was then multiplied by two and the result used with a line chart for calculating the fitness index. The test was specifically designed to determine fitness for hard work.

The Step Test is not highly valid because there is no criteria against which to compare itself; the pulse rate itself being the criterion. Direct correlations between various types of endurance performances in determining the validity of these types of tests might present better evidence in this area of physical fitness. Some studies have been made in which the Step Test was correlated against other types of endurance performances, and the results showed low correlations.

K. A. Bookwalter's[2] "Study of the Brouha Step Test," which

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[1]R. E. Johnson, L. Brouha and R. C. Darling, "A Test of Physical Fitness for Strenous Exertion," Revue canadienne de Biologie, 1: pp. 491-503, June 1942.

[2]K. A. Bookwalter, "A Study of the Brouha Step Test," The Physical Educator, Volume V., Number 3, p. 55, May 1948.

was administered to 1,269 A.S.T.P. students, using a five minute workload and a 19-inch bench, came to the following conclusion:

1. The Step Test is insignificantly related to the factors studied (age, height, weight, 300 yard dash).

2. Of the items correlated there is slightly more relationship (inversely) between the Brouha Step Test and height than between the other items.

3. There appears to be a low negative relationship between the Step Test, age, and height.

4. Since 32 cases of 68 or more inches height (2.5%) score over 104 and no cases below 68 inches tall score over 104, shortness would seem to preclude high scores on the Brouha Step Test.

Elbel and Green[1] demonstrated that "the Step Test exercise for 30 and 60 seconds on benches 12-20 inches in height with pulse rates taken for 30 seconds beginning 60 seconds after the exercise, is practically the same for the various height benches and the short and longer exercises."

McCloy's Endurance Ratio[2] is an endurance test in which the individual runs a 220-yard dash and a 60-yard dash, with the time made on the 60-yard dash being divided into the time made on the 220-yard dash to give an endurance ratio. The basic principle of this test lies in the fact that if an individual can run the 220-yard dash at approximately the same rate

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[1]E. R. Elbel and Earl L. Green, "Pulse Reaction to Performing Step-Up Exercise on Benches of Different Heights," American Journal of Physiology, 145: pp. 521-527, 1946.

[2]C. H. McCloy, Tests and Measurements in Health and Physical Education, New York: F. S. Crofts & Co., p. 135.

as that of the 60-yard dash time, his endurance is assumed to be superior.

Bell's[1] study reported that Flanagan used McCloy's Ratio as a criterion of endurance in seeking to establish the pulse ratio test as a measure of endurance in running. A high correlation was obtained after the omission of cases that were distinctly away from the regression line. But Henry and Kleeberger[2] did further work or analysis and feel doubtful about Flanagan's correlation. Holding the factor of speed constant in their study, the indication was that the influence of the speed factor is not removed with such an index.

Research Evidence Pertinent to the other Physiological Variables Considered in the Study

Dimock[3] stresses the following points in reference to physiological age characteristics:

1. There is an association of some kind between the socio-economic background of boys, physical size, and probably intelligence and age at which he becomes pubescent.

2. Crampton's criteria for physiological age grouping is validated by microscopic examinations of secretions.

3. Boys become pubescent at greatly varying ages,

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[1]T. B. Bell, "The Validity of Certain Tests of Endurance," Research Quarterly, 19: 229, 1948.

[2]F. M. Henry and F. L. Kleeberger, "The validity of the Pulse Ratio test of cardiac efficiency," Research Quarterly, 9(2):32-46, 1938.

[3]H. S. Dimock, Rediscovering the Adolescent, New York: Association Press, 1937, p. 213.

ranging at least from ten to sixteen.

4. Physical stature seems to affect the age at which boys become pubescent.

5. Average age of puberty assumed to be 14 years.

6. Rapidity of maturing at puberty period is dependent more on physiological than chronological age.

7. A high heart rate indicates poor condition.

Crampton's[1] criteria is based upon the facts that the period of pre-pubescence begins at birth and ends at the beginning of pubescence, and all in this period are classed as pre-pubescent. All those who have completed their pubescence are classified as post-pubescent. The change from the pre-pubescent level to the pubescent is a gradual process. The transition is begun by an evident and rapid growth of the fine hair apparently already present. The second period of pubescence begins with the pigmentation of the exaggerated hair growth, and pubescence ends with the appearance of the kink or twist.

Godin and Demeny[2] have presented data to show that regular exertion in the pre-adolescent period develops the body.

Dr. Jokl's[3] research findings on boys and girls, under the auspices of the South African Institute for Medical Research, reached the conclusion after testing several thousand youngsters that the hardest type of physical exertion has never hurt a normal individual.

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[1] Ibid., p. 213.

[2] T. K. Cureton, op. cit., p. 316.

[3] T. K. Cureton, op. cit., p. 315.

Brock[1] did a study of heart rate from the standpoint of physiological age. His conclusions were:

1. the change from pre-pubescent to pubescent or post-pubescence, is in some cases rapid. A boy can go through the pubescence period in four months.

2. in comparing the heart rates of the three groups the following points were observed:

   a. variability was greater in pubescents and post-pubescents than in pre-pubescents in both horizontal and vertical positions
   b. there was a greater percentage of pre-pubescents in smaller range than other groups
   c. pubescent boys are more unevenly distributed than the other two groups
   d. pubescent boys have a greater number in the high heart rate.

3. paper route boys showed no decrease in heart rate or marked difference in variation from the general average.

4. rapid gain in height and weight is related to pubescent period and particularly to later stages of pubescence.

5. average heart rate of rapid growers is slightly higher than the general average, but variation is about the same.

6. those who besides gaining an inch in height gained as much as five pounds or over in weight were still higher in heart rate in both horizontal and vertical positions.

A study involving the variable of body surface area was that of Brouha and Gallagher's[2] "A Simple Method of Testing Physical Fitness." It divided boys into two groups on the

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[1]J. D. Brock, "Heart Rate in Relation to Adolescence", Thesis, Springfield College, 1920.

[2]J. R. Gallagher and Lucien Brouha, "A Simple Method of Testing the Physical Fitness of Boys," Research Quarterly, 14: 31-35, March, 1943.

basis of surface area using a nomographic chart. The smaller body surface area group used an eighteen inch platform, and the larger body surface area group used a twenty inch platform. The test consisted of stepping thirty times a minute up and down on the platform for four minutes. Their conclusion was that the step test is useful in determining physical fitness before a training program starts. In this way the trainer can put low scores in one group, fairly low in another and high scores in another, and subsequently each of those groups can be given physical training appropriate to their degree of fitness.

Another study by Brouha and Gallagher[1] have subjects using a bicycle ergometer at the rate of twenty miles per hour against a friction load of five pounds for five minutes. A cardio-tachometer was used to record heart rate. The summary was as follows:

1. Work was kept constant to measure physical efficiency for hard work.
2. Test conditions were found to be too severe for the majority of smaller subjects and this was apparently affected more by size than age or fitness.
3. Fitness could not be predicted from one observation of maximum heart rate alone.
4. The desirability of opportuning test work within members of this age group, on the basis of size is indicated.

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[1]J. R. Gallagher and Lucien Brouha, "Physical Fitness in Adolescence," Yale Journal of Biology and Medicine, 15, 1942-1943.

5. The advisibility of adjusting work load on the basis of subject's body surface.

6. Indication that physical efficiency increases in relation to size rather than age.

7. Indication that a relationship between work indices and recovery indices exists.

Dane's[1] study of the McCurdy-Larson Organic Efficiency Test in relation to physiological age came to the following conclusions:

1. A gradual change takes place in the physiological variables as age increases from pre-pubescence to post-pubescence.

2. The least change is noticed between the pre-pubescent and pubescent, and the greatest change between the pre-pubescent and post-pubescent.

3. Post-pubescent boys are highly superior, pre-pubescent are least efficient in circulatory-respiratory function.

4. The three physiological age groupings are significantly different and each needs a scoring table by which to calculate the circulatory-respiratory efficiency of a boy according to his growth status.

In relation to heart rate performances of boys, Boas[2] using a cardiotachometer to observe heart rate reaction during and after exercise indicated the following:

1. A very high miximum heart rate was shown by most of the boys (ages 9 to 15)

2. Rise in heart rate with exercise depends in part on

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[1]C. W. Dane, " A Study of Circulatory-Respiratory Changes as Indicated by the McCurdy-Larson Organic Efficiency Test in Relation to Physiological Age," Research Quarterly, 15: pp. 98-112, May 1944.

[2]E. P. Boas, "Heart Rate of Boys During and After Exhausting Exercises," Journal of Clinical Investigation, 1931.

the amount of work performed and in part on the speed with which it is carried on.

3. The difference between heart rate of the boys does not necessarily show itself in the absolute height to which the heart rises, as by the time of occurrence of the maximum in each case.

4. The increment in rate was the greater, the lower the initial heart rate.

5. Acceleration of the pulse begins immediately with exercise.

6. Deceleration begins just as promptly, and within the first minute after exercise the major drop in rate is already completed.

7. In boys who were in better physical condition, the reduction in heart rate after exercise occurred a little more rapidly.

Schneider and Crampton's[1] study of pre-adolescent boys and their reactions to various amounts of muscular exercise indicated:

1. When subjected to short periods of work of graded intensity, the pre-adolescent failed to show linear relationship between load of work and pulse rate that occurs among adults. A boy who had just entered pubescence gave a good illustration of this linear relationship.

2. For all of the pre-adolescents 6000 ft. lbs. was clearly an overload of work.

3. The minute volume output of the heart was also less among the boys than among men but not proportionately the same as that of the stroke volume. The greater frequency of the heart beat tended to offset the smaller stroke volume.

In relation to the variable of body weight, it was stated

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[1] C. B. Crampton and Schneider, "Cardiovascular Responses of Pre-Adolescent Boys to Muscular Activity," American Journal of Physiology, 114: 473, 1936.

by Elbel[1] in his study that, "the coefficient of correlation between body weight and increased pulse rate due to exercise is insignificant."

In a study by Ferguson[2] one of his conclusions states that, "the difference between normal pulse rate after exercise showed changes in all groups, the most significant between the extreme (14 to 17) age group." This study was based on chronological age grouping of adolescent boys from ages thirteen and a half to seventeen and one half.

There were no pertinent findings in relation to the variable of leg length.

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[1]E. R. Elbel, "The Relationship Between Pre-Exercise and Post-Exercise Pulse Rate," Research Quarterly, 19 (3): 222, October 1948.

[2]W. J. Ferguson, A Normative Study of the McCurdy-Larson Organic Efficiency Test for Adolescent Boys, Thesis, Springfield College, 1939.

CHAPTER II

METHODS OF COLLECTING DATA

Selection of cardiovascular tests for the study. The literature was reviewed for the purpose of selecting the endurance tests which would be most satisfactory for accomplishing the objectives of the study. The Brouha Test and McCloy's Endurance Index were selected because the time element involved was as short as could be found in any of the other tests. These tests were also applicable for the purpose of measuring the influences of the variables to be used in the study.

The physical directors of the school systems of Weston, and Concord, Massachusetts were visited and the purpose of the study was explained to them. The physical directors readily agreed to cooperate as much as possible and permission to do the testing and collect the data was granted officially. A preliminary study on a limited number of boys to determine the most practicable workload and bench height to be used, was administered in the Weston school. Fifteen boys were selected on the basis of physiological age (pre-pubescent to post-pubescent).

A preliminary study to decide upon suitable distances for the McCloy Ratio of Endurance, administered at the Concord school to a sampling of fifteen boys ranging from pre-pubescent

to post-pubescent, using Crampton's criteria for physiological age grouping, indicated that sixty yards and 220 yards would be suitable. The main emphasis of the preliminary studies was to adapt the tests to the subjects with the hope that the reaction would not permit undue distress or on the other hand would not be too moderate.

It was definitely decided to use the following:

1. An eighteen-inch bench and a four minute workload for the Harvard Step Test;
2. A metronome clocking of 126 to give 120 full steps up and down on the bench per minute;
3. A straightaway grass area, for the sixty yard and 220 yard dashes, eliminating the factor of skill in running the curves on a regulation running track;
4. Each boy would be clocked at the ten yard mark on each run to eliminate the factor of starting skill. This holds constant the factor of starting skill.

A data sheet was constructed to record the data. The data sheet can be found in the appendix.

The physical director and nurse of each school assured the writer that every boy to be tested had been medically examined during the year, and those who were not fit for the testing were eliminated.

To facilitate the best possible conditions under which the tests were to be administered, the facilities selected were:

1. Harvard Step Test
   a. Weight-room in the Concord school
   b. Locker-room in the Weston school
2. McCloy's Endurance Index
   a. Grass area of the school playground facilities

The weight and locker-rooms provided the best opportunity for quiet and privacy, and the grass areas furnished a straight run lane.

The instructions and procedures for the administration of the Step Test and the McCloy Endurance Run. The following equipment was used:

1. One platform, eighteen inches high
2. Four stop watches
3. Two stethescopes
4. One metronome
5. Standard scale for height and weight measurements
6. A homemade stadiometer consisting of a bench forty centimeters in height and fifteen centimeters in width; a strip of adhesive tape, taped to the wall and graduated in inches, and an angle with a crosspiece attached as a handle to measure the sitting height when the angle's horizontal surface is set on top of the head of each boy.
7. A nomographic chart to calculate surface area
8. A data sheet to record the results of the tests and measurements

To follow a regular schedule and to interfere as little as possible with the regular program of physical education in both schools, the physical education class schedules were studied to enable a majority of the boys to be measured for height, weight, physiological age, and sitting height one to three days before the testing took place. The name, chronological age, and control (non-varsity) or experimental (varsity) classification of each boy was also recorded. The schedule was also used to aid in arranging to give both tests within a period of two days in most cases, and three to five days in a smaller number of cases for the purpose of attaining the best possible standardization of testing conditions as was possible in the situation under which the study was made. In following the class schedule, it was also possible, in most cases, to give both tests to each boy at the same time of day.

A practice teacher in Concord High School was selected and trained to assist the writer in checking cadence of the step test; clocking; measuring height, weight, and sitting height; judging physiological age; and recording heart rate with the stethescope.

Students who were unable to take the tests, assisted in recording the scores made during the period of testing.

The subjects were given clear and concise directions as to the purpose of the testing and performance. A checklist criteria, listing causes for elimination from the testing, is indicated on the data sheet.

In directing the performance of the tests, the following procedures were adhered to:

Step Test

At the signal to start, the subject places one foot on the platform, steps up, placing both feet fully on the platform, straightens his legs and back, and immediately steps down again, one foot at a time. The pace is set by the metronome. The observer repeated the rhythm of the metronome in a loud voice at the start of the test, and during intervals whenever a subject faltered. The subject is instructed to lead off with either foot when starting, and change the foot he started to step up with, only when the leg became tired if he so desired.

The observer begins clocking the time when the subject starts, and at the end of the four minute period, the subject stops and sits down. The observer places the stethescope on the apex of the heart and records the heart-rate count one minute to one minute and a half, two minutes to two minutes and a half, and three minutes to three minutes and a half after the subject stops working.

The following technique was adopted to facilitate testing as many boys as possible during the time allowed: a subject started and worked for four minutes. Immediately afterward, the clock was clicked back to zero and another subject was told to start, thereby having a record of timing in which the heart rate count of the subject who had just finished could be recorded. At the same time, a record of the time of the

subject just starting could be kept. A similar technique is to have another stop watch available so that when one subject stops after a four minute work period, a new subject could start and his time can be recorded with the second watch, while the first subject's heart beat count is being recorded. This technique saves a period of time of three and one half minutes which would have to be allowed if the observer waited until he had recorded the heart beat count before testing a new subject.

Calculation of the Score

The three and one half-minute counts of the pulse are added and multiplied by two. The duration of exercise in seconds is multiplied by 100 and divided by the sum of the pulses.

McCloy Endurance Index

The subjects were instructed to run at full speed in the sixty yard dash, and to take a moderately fast start and maintain a steady pace throughout the 220 yard run. The preliminary warm-up consisted of:

a. jogging a lap

b. striding near the end of the lap

c. practice of a few starts at three-quarter speed.

A starter stood at the ten yard mark and brought his upraised arm down as a signal to start clocking, after he had given the go sign to the subject. The subjects were started

one after the other in the sixty yard dash, with the observer using two stop watches to clock each subject. For the 220-yard run, the same procedure was followed as in the sixty yard dash except that enough time was allowed for one subject to run approximately fifty yards before the next subject started. This eliminated confusion in clocking the subjects as they finished. A recovery time of one to two minutes was allowed between runs. The availability of more assistants would have enabled the administering of the test to a greater number of subjects at one time, but this was not possible.

Calculation of the Score

The fifty yard time made by a subject was divided into the 210-yard time to get an endurance ratio.

The activity program at the Weston School was: Physical Education, two days a week; at the Concord School: four days a week. The activities at both schools consisted of basketball, apparatus, softball, and track, during the time when the research was conducted.

The majority of completed cases were gathered in the Concord school system. The number and dates of the testing period were:

Pre-pubescent

Number: 22
Date: April 1 to April 11, 1949

Number: 9
Date: April 12 to April 15, 1949

Number: 13
Date: April 25 to May 2, 1949

Pubescent
Number: 18
Date: April 1 to April 15, 1949

Post-pubescent
Number: 99
Date: April 1 to April 7, 1949

Number: 12
Date: April 12 to April 15, 1949

A standard scale was used to measure height and weight. Height was measured to the nearest quarter inch and weight was measured to the nearest quarter pound. Each subject was in his stocking feet when weighed and measured for height.

Sitting height was measured to the nearest quarter inch with each subject sitting straight and placing his head against the tape measure attached to the wall. A level was placed on top of the subject's head to obtain a record of sitting height.

The physiological age of each subject was checked by the author and the assistant. Each observed the pubic hair grouth of each subject as designated by Crampton's[1] criteria. The writer and the assistant checked each other's analysis before deciding on the proper classification of the subject.

An explanation of the purpose of the physiological age grouping was made to the subjects because of their obvious curiosity during the testing period.

Varsity and non-varsity classifications were made by asking each subject to state if he was or was not participating in the varsity sports of the school.

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[1]H. S. Dimock, op. cit., p. 213.

The body surface area was calculated by:

1. changing the standing height into centimeters. (One inch equals 2.56 centimeters) Then 2.56 centimeters was multiplied by the standing height of each subject.
2. Two and two-tenths pounds which is equal to one kilogram, was divided into the weight of each subject to obtain a record of weight in kilograms.
3. Dubois's[1] chart for determining surface area from weight in kilograms and height in centimeters was used to read off approximate surface area in square meters.

The criteria used for the purpose of eliminating subjects from the testing was taken from Dane's[2] study. There were only a few subjects eliminated through the use of the criteria during the study.

One hundred and seventy-two subjects were completely tested in regards to all the items mentioned in the study. Of the 172 subjects, 44 were pre-pubescent, 18 were pubescent, and 111 were post-pubescent.

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[1]Henry C. Sherman, Chemistry of Food and Nutrition, Macmillan Company, New York, 1946, p. 160.

[2]C. W. Dane, "A Study of the Circulatory-Respiratory changes as indicated by the McCurdy-Larson Organic Efficiency Test in relation to physiological age," Research Quarterly, 15: pp. 98-112, May 1944.

CHAPTER III

ANALYSIS AND INTERPRETATION OF THE DATA

The statistical analysis of data in the following tables consists of measures of mean, standard deviation, standard error of the mean, difference of means, standard error of the difference, critical ratio, and zero order intercorrelations. The number of cases in each maturity level are:

1. pre-pubescent, 44
2. pubescent, 18
3. post-pubescent, 111

The number of cases in the varsity and non-varsity grouping on the post-pubescent level are:

1. varsity, 43
2. non-varsity, 68

The purpose of the study is to test the hypothesis that the Harvard Step Test and the McCloy Endurance Ratio should correlate moderately high as measures of endurance. If the correlation is not moderately high, then the influences of the other variables such as leg length, height, weight, physiological age, and body surface area must be indicated through an analysis and interpretation of the findings of the study. The 1% level of significance was chosen and represents a critical ratio of 2.56.

The tables will show:

1. Intercorrelations of the Endurance Tests and the

variables

2. a statistical analysis of the Harvard Step Test and the McCloy Endurance Ratio between the maturity levels

3. a statistical analysis of the Harvard Step Test and the McCloy Endurance Ratio between the varsity and non-varsity in the post-pubescent maturity level

4. a statistical analysis of the variable of leg length involving the maturity levels of pre-pubescence and post-pubescence. Comparisons will be made between high and low leg length scores, and corresponding high and low Harvard Step Test and McCloy Endurance Ratio scores. This will be done to see if there is a significant difference in the scores for subjects having different leg lengths at the following levels of maturity:

a. pre-pubescent
b. comparison between post-pubescent and pre-pubescent
c. post-pubescent (non-varsity)
d. post-pubescent (varsity)
e. post-pubescent (varsity and non-varsity combined)

The twenty highest and the twenty lowest scores of leg length were used on the post-pubescent level. The fifteen highest and the fifteen lowest scores of leg length on the pre-pubescent level were used.

TABLE 1

INTERCORRELATIONS OF THE ENDURANCE TESTS AND THE VARIABLES

pre-pubescent	Harvard Test	McCloy Ratio	.064
post-pubescent	Harvard Test	McCloy Ratio	-.115
pre-pubescent	Harvard Test	Height	.070
pre-pubescent	Harvard Test	Body Surface	.025
pre-pubescent	Harvard Test	Leg Length	.050
pre-pubescent	Harvard Test	Weight	-.035
pre-pubescent	McCloy Ratio	Height	.05
pre-pubescent	McCloy Ratio	Weight	-.019
pre-pubescent	McCloy Ratio	Leg Length	-.213
pre-pubescent	McCloy Ratio	Body Surface	.054
post-pubescent	Harvard Test	Height	.0041
post-pubescent	Harvard Test	Leg Length	.060
post-pubescent	Harvard Test	Weight	.095
post-pubescent	Harvard Test	Body Surface	.0824
post-pubescent	McCloy Ratio	Body Surface	.225
post-pubescent	McCloy Ratio	Weight	.248
post-pubescent	McCloy Ratio	Height	.194
post-pubescent	McCloy Ratio	Leg Length	.127

TABLE 2

COMBINED MATURITY LEVELS OF

PRE-PUBESCENT PUBESCENT POST-PUBESCENT

Harvard Step Test	McCloy Endurance Ratio	-.044
Harvard Step Test	Leg Length	.085
Harvard Step Test	Weight	.045
Harvard Step Test	Body Surface Area	.080
Harvard Step Test	Height	.052
McCloy Endurance Ratio	Leg Length	.047
McCloy Endurance Ratio	Height	.107
McCloy Endurance Ratio	Weight	.191
McCloy Endurance Ratio	Body Surface Area	.157

The significance ratio (2.58) will be used for significance at the 1% level.

TABLE 3

STATISTICAL ANALYSIS OF THE HARVARD STEP TEST BETWEEN

THE PRE-PUBESCENT AND PUBESCENT GROUPS

	N	MEAN	S.D.	SE_M	Diff. M_1-M_2	$SE_{Diff.}$	C. R.
pre-pubescent	44	67	6.9	1.04	0		
pubescent	18	67	10	2.43			

The results indicate that no difference exists between the means of the pre-pubescent and pubescent groups.

TABLE 4

STATISTICAL ANALYSIS OF THE MCCLOY ENDURANCE RATIO TEST BETWEEN THE PRE-PUBESCENT AND PUBESCENT GROUPS

	N	MEAN	S.D.	SE_M	Diff. M_1-M_2	$SE_{Diff.}$	C. R.
pre-pubescent	44	4.4	.350	.052	0	-	0
pubescent	18	4.4	.450	.109			

The results indicate that no difference exists between the means of the pre-pubescent and pubescent groups.

TABLE 5

STATISTICAL ANALYSIS OF THE HARVARD STEP TEST BETWEEN THE PRE-PUBESCENT AND POST-PUBESCENT GROUPS

	N	MEAN	S.D.	SE_M	Diff. M_1-M_2	$SE_{Diff.}$	C.R.
pre-pubescent	44	67	6.9	1.04	1.5	1.33	1.12
post-pubescent	111	68.5	8.7	.828			

The results indicate a difference in the means of 1.5 in favor of the post-pubescent group, giving a C. R. of 1.12. This C. R. indicates that, at the 1% level of significance,

there are 26 chances in 100 of a difference occurring by chance.

TABLE 6

STATISTICAL ANALYSIS OF THE McCLOY ENDURANCE RATIO TEST BETWEEN THE PRE-PUBESCENT AND POST-PUBESCENT GROUPS

	N	MEAN	S.D.	SE_M	Diff. M_1-M_2	$SE_{Diff.}$	C. R.
pre-pubescent	44	4.44	.350	.057	.08	.072	1.11
post-pubescent	111	4.52	.476	.041			

The results indicate a difference in the means of .08 in favor of the post-pubescent group, giving a C. R. of 1.11. This C. R. indicates that at the 1% level of significance, there are 26 chances in 100 of a difference occurring by chance.

TABLE 7

STATISTICAL ANALYSIS OF THE HARVARD STEP TEST BETWEEN THE PUBESCENT AND POST-PUBESCENT GROUPS

	N	MEAN	S.D.	SE_M	Diff. M_1-M_2	$SE_{Diff.}$	C. R.
post-pubescent	111	68.5	8.7	.828	1.5	2.55	.588
pubescent	18	67	10	2.42			

The results indicate that the difference between the means is 1.5 in favor of the post-pubescent group, giving a C. R. of .588. This C. R. indicates that the level of significance is very small, and that there are 55 chances in 100 of a difference occurring by chance.

TABLE 8

STATISTICAL ANALYSIS OF THE MCCLOY ENDURANCE RATIO TEST BETWEEN THE PUBESCENT AND POST-PUBESCENT GROUPS

	N	MEAN	S.D.	SE_M	Diff. M_1-M_2	$SE_{Diff.}$	C. R.
post-pubescent	111	4.52	.476	.453	.12	.465	.258
pubescent	18	4.4	.450	.109			

The results indicate that the difference between the means is .12 in favor of the post-pubescent group, giving a C. R. of .258. This C. R. indicates that the level of significance is very small, and that there are 80 chances in 100 of a difference occurring by chance.

TABLE 9

STATISTICAL ANALYSIS OF THE HARVARD STEP TEST BETWEEN THE VARSITY AND NON-VARSITY GROUPS IN THE POST-PUBESCENT MATURITY LEVEL

	N	MEAN	S.D.	SE_M	Diff. M_1-M_2	$SE_{Diff.}$	C. R.
varsity	43	67.6	7.95	1.21	1.1	1.59	.691
non-varsity	68	68.7	8.5	1.03			

The results indicate that the difference between the means is 1.1 in favor of the non-varsity group, giving a C. R. of .691. This C. R. indicates that the significance level is very small, and that there are 49 chances in 100 of a difference occurring by chance.

TABLE 10

STATISTICAL ANALYSIS OF THE McCLOY ENDURANCE RATIO TEST BETWEEN THE VARSITY AND NON-VARSITY GROUPS IN THE POST-PUBESCENT MATURITY LEVEL

	N	MEAN	S.D.	SE_M	Diff. M_1-M_2	$SE_{Diff.}$	C. R.
varsity	43	4.60	.416	.063	.12	.087	1.37
non-varsity	68	4.48	.498	.060			

The results indicate that the difference between the means is .12 in favor of the varsity group, giving a C. R. of 1.37. This C. R. indicates that the difference is not statistically significant at the 1% level, and that there are 17 chances in 100 of a difference occurring by chance.

TABLE 11

STATISTICAL ANALYSIS OF HIGH AND LOW LEG LENGTH MEASUREMENTS IN THE PRE-PUBESCENT GROUP (NON-VARSITY)

	N	MEAN	S.D.	SE_M	Diff. M_1-M_2	$SE_{Diff.}$	C.R.
High Leg Length	15	85	10.59	2.83	14.9	3.07	4.85
Low Leg Length	15	70.1	4.50	1.20			

The results indicate a difference in the means of 14.9 in favor of the high leg length scores, giving a C. R. of 4.85 which is statistically significant at the 1% level.

TABLE 12

STATISTICAL ANALYSIS OF THE HARVARD STEP TEST SCORES ON THE HIGH AND LOW LEG LENGTH ON THE PRE-PUBESCENT LEVEL (NON-VARSITY)

	N	MEAN	S.D.	SE_M	Diff. M_1-M_2	$SE_{Diff.}$	C. R.
High	15	67.43	8.44	2.25	1.07	2.68	.399
Low	15	66.36	5.48	1.46			

The results indicate a difference in the means of 1.07 in favor of the high leg length sampling, giving a C. R. of .399. This C. R. indicates that the difference is not statistically significant at the 1% level, and there are 69 chances in 100 of

a difference occurring by chance.

TABLE 13

STATISTICAL ANALYSIS OF THE McCLOY ENDURANCE RATIO SCORES ON THE HIGH AND LOW LEG LENGTH

	N	MEAN	S.D.	SE_M	Diff. M_1-M_2	$SE_{Diff.}$	C. R.
Low pre-pubescent	15	4.57	.472	.126	.29	.152	1.90
High pre-pubescent	15	4.28	.322	.086			

The results indicate a difference in the means of .29 in favor of the low leg length, giving a C. R. of 1.90. This C. R. indicates that the difference is not statistically significant at the 1% level, and there are 5 chances in 100 of a difference occurring by chance.

TABLE 14

STATISTICAL ANALYSIS OF THE HIGH LEG LENGTH MEASUREMENTS BETWEEN THE POST-PUBESCENT AND PRE-PUBESCENT SAMPLINGS (NON-VARSITY)

	N	MEAN	S.D.	SE_M	Diff. M_I-M_2	$SE_{Diff.}$	C. R.
post-pubescent	20	88.1	3.19	.733	3.1	2.92	1.06
pre-pubescent	15	85	10.59	2.83			

The results indicate a difference in the means of 3.1 in favor of the post-pubescent, giving a C. R. of 1.06. This

C. R. indicates that the difference is not statistically significant at the 1% level, and that there are 29 chances in 100 of a difference occurring by chance.

TABLE 15

STATISTICAL ANALYSIS OF THE LOW LEG LENGTH MEASUREMENTS BETWEEN THE POST-PUBESCENT AND PRE-PUBESCENT SAMPLINGS (NON-VARSITY)

	N	MEAN	S.D.	SE_M	Diff. M_1-M_2	$SE_{Diff.}$	C. R.
post-pubescent	20	76.26	2.73	.627	6.16	1.35	4.56
pre-pubescent	15	70.1	4.50	1.20			

The results indicate a difference in the means of 6.16 in favor of the post-pubescent, giving a C. R. of 4.56. This C. R. indicates that the difference is statistically significant at the 1% level.

TABLE 16

STATISTICAL ANALYSIS OF THE HARVARD STEP TEST SCORES OF HIGH LEG LENGTH BETWEEN THE POST-PUBESCENT AND PRE-PUBESCENT GROUPS (NON-VARSITY)

	N	MEAN	S.D.	SE_M	Diff. M_1-M_2	$SE_{Diff.}$	C. R.
post-pubescent	20	70.6	8.55	1.96	3.2	2.98	1.07
pre-pubescent	15	67.4	8.44	2.25			

The results indicate a difference of 3.2 in the means favoring the post-pubescent, giving a C. R. of 1.07. This C.R. indicates that the difference is not statistically significant at the 1% level, and that there are 28 chances in 100 of a difference occurring by chance.

TABLE 17

STATISTICAL ANALYSIS OF THE HARVARD STEP TEST SCORES OF LOW LEG LENGTH BETWEEN THE POST-PUBESCENT AND PRE-PUBESCENT GROUPS (NON-VARSITY)

	N	MEAN	S.D.	SE_M	$M_{Diff.}$ M_1-M_2	$SE_{Diff.}$	C. R.
post-pubescent	20	69.85	10.41	2.39	3.49	2.80	1.24
pre-pubescent	15	66.36	5.48	1.46			

The results indicate a difference of 3.49 in the means favoring the post-pubescent, giving a C. R. of 1.24. This C. R. indicates that the difference is not statistically significant at the 1% level, and that there are 21 chances in 100 of a difference occurring by a chance.

TABLE 18

STATISTICAL ANALYSIS OF THE McCLOY ENDURANCE RATIO SCORES OF LOW LEG LENGTH BETWEEN THE POST-PUBESCENT AND PRE-PUBESCENT GROUPS (NON-VARSITY)

	N	MEAN	S.D.	SE_M	Diff. M_1-M_2	$SE_{Diff.}$	C. R.
post-pubescent	20	4.30	.516	.118	.27	.172	1.56
pre-pubescent	15	4.57	.472	.126			

The results indicate a difference in the means of .27 favoring the pre-pubescent, giving a C. R. of 1.56. This C. R. indicates that the difference is not statistically significant at the 1% level, and that there are 12 chances in 100 of a difference occurring by chance.

TABLE 19

STATISTICAL ANALYSIS OF THE McCLOY ENDURANCE RATIO SCORES OF HIGH LEG LENGTH BETWEEN THE POST-PUBESCENT AND PRE-PUBESCENT GROUPS (NON-VARSITY)

	N	MEAN	S.D.	SE_M	Diff. M_1-M_2	$SE_{Diff.}$	C. R.
post-pubescent	20	4.44	.434	.099	.16	.131	1.22
pre-pubescent	15	4.28	.344	.066			

The results indicate a difference in the means of .16 favoring the post-pubescent, giving a C. R. of 1.22. This C. R. indicates that the difference is not statistically significant at the 1% level, and that there are 22 chances in 100 of a difference occurring by chance.

TABLE 20

STATISTICAL ANALYSIS OF HIGH AND LOW LEG LENGTH MEASUREMENTS IN THE POST-PUBESCENT GROUP (NON-VARSITY)

	N	MEAN	S.D.	SE_M	Diff. M_1-M_2	$SE_{Diff.}$	C. R.
High Leg Length	20	88.1	3.19	.733	11.84	.964	12.2
Low Leg Length	20	76.26	2.73	.627			

The results indicate a difference in the means of 11.84 favoring the high leg length sampling, giving a C. R. of 12.2. This C. R. indicates that the difference is statistically significant at the 1% level.

TABLE 21

STATISTICAL ANALYSIS OF THE HARVARD STEP TEST SCORES ON HIGH AND LOW LENGTH IN THE POST-PUBESCENT GROUP (NON-VARSITY)

	N	MEAN	S.D.	SE_M	Diff. M_1-M_2	$SE_{Diff.}$	C. R.
High Leg Length	20	70.6	8.55	1.96	.75	3.09	.242
Low Leg Length	20	69.85	10.41	2.39			

The results indicate a difference in the means of .75 favoring the high leg length, giving a C. R. of .242. This C. R. indicates that the difference is statistically insignificant at the 1% level, and that there are 81 chances in 100 of a

difference occurring by chance.

TABLE 22

STATISTICAL ANALYSIS OF THE McCLOY ENDURANCE RATIO SCORES ON HIGH AND LOW LEG LENGTH IN THE POST-PUBESCENT GROUP (NON-VARSITY)

	N	MEAN	S.D.	SE_M	Diff. M_1-M_2	$SE_{Diff.}$	C. R.
High Leg Length	20	4.44	.434	.099	.14	.154	.909
Low Leg Length	20	4.30	.516	.118			

The results indicate a difference in the means of .14 favoring the high leg length, giving a C. R. of .909. This C. R. indicates that the difference is statistically insignificant at the 1% level, and there are 36 chances in 100 of a difference occurring by chance.

TABLE 23

STATISTICAL ANALYSIS OF THE HIGH AND LOW LEG LENGTH MEASUREMENTS IN THE POST-PUBESCENT GROUP (VARSITY)

	N	MEAN	S.D.	SE_M	Diff. M_1-M_2	$SE_{Diff.}$	C. R.
High Leg Length	20	88.75	6.54	1.50	10.35	1.94	5.33
Low Leg Length	20	78.4	5.42	1.24			

The results indicate a difference in means of 10.35 favoring

the high leg length, giving a C. R. of 5.33. This C. R. indicates that the difference is statistically significant at the 1% level.

TABLE 24

STATISTICAL ANALYSIS OF THE HARVARD STEP TEST SCORES ON THE HIGH AND LOW LEG LENGTH IN THE POST-PUBESCENT GROUP (VARSITY)

	N	MEAN	S.D.	SE_M	$M_{Diff.}$ M_1-M_2	$SE_{Diff.}$	C. R.
High Leg Length	20	69.55	8.04	1.84	3.60	2.49	1.44
Low Leg Length	20	65.95	7.29	1.69			

The results indicate a difference in the means of 3.60 favoring the high leg length, giving a C. R. of 1.44. This C. R. indicates that the difference is statistically insignificant at the 1% level, and that there are 15 chances in 100 of a difference occurring by chance.

TABLE 25

STATISTICAL ANALYSIS OF THE McCLOY ENDURANCE RATIO TEST SCORES ON THE HIGH AND LOW LEG LENGTH IN THE POST-PUBESCENT GROUP (VARSITY)

	N	MEAN	S.D.	SE_M	Diff. M_1-M_2	$SE_{Diff.}$	C. R.
High Leg Length	20	4.56	.406	.093	.01	.130	.0769
Low Leg Length	20	4.57	.404	.092			

The results indicate a difference in the means of .01 favoring the low leg length, giving a C. R. of .0769. This C. R. indicates a statistically insignificant difference at the 1% level, and that there are 93 chances in 100 of a difference occurring by chance.

TABLE 26

STATISTICAL ANALYSIS OF THE HIGH AND LOW LEG LENGTH MEASUREMENTS IN THE POST-PUBESCENT GROUP (VARSITY AND NON-VARSITY COMBINED)

	N	MEAN	S.D.	SE_M	Diff. M_1-M_2	$SE_{Diff.}$	C. R.
High Leg Length	20	91.7	5.43	1.24	16.5	1.65	10.0
Low Leg Length	20	75.2	4.78	1.09			

The results indicate a difference in the means of 16.5 favoring the high leg length, giving a C. R. of 10. This C. R. indicates a difference in the means that is statistically significant at the 1% level.

TABLE 27

STATISTICAL ANALYSIS OF THE McCLOY ENDURANCE RATIO TEST SCORES ON THE HIGH AND LOW LEG LENGTH IN THE POST-PUBESCENT GROUP (VARSITY AND NON-VARSITY COMBINED)

	N	MEAN	S.D.	SE_M	Diff. M_1-M_2	$SE_{Diff.}$	C. R.
High Leg Length	20	4.52	.490	.112	.20	.143	1.39
Low Leg Length	20	4.32	.390	.089			

The results indicate a difference in the means of .20 favoring the high leg length, giving a C. R. of 1.39. This C. R. indicates a difference in the means that is statistically insignificant at the 1% level, and that there are 16 chances in 100 of a difference occurring by chance.

TABLE 28

STATISTICAL ANALYSIS OF THE HARVARD STEP TEST SCORES ON HIGH AND LOW LEG LENGTH IN THE POST-PUBESCENT (VARSITY AND NON-VARSITY COMBINED)

	N	MEAN	S.D.	SE_M	Diff. M_1-M_2	$SE_{Diff.}$	C. R.
High Leg Length	20	70.15	7.83	1.8	.30	2.63	.114
Low Leg Length	20	69.85	8.40	1.93			

The results indicate a difference in the means of .30 favoring the high leg length, giving a C. R. of .114. This C. R.

indicates a difference in the means that is statistically insignificant at the 1% level, and that there are 91 chances in 100 of a difference occurring by chance.

COMPARISON OF STATISTICAL ANALYSIS RESULTS BETWEEN VARSITY AND NON-VARSITY GROUPS ON THE POST-PUBESCENT LEVEL

A statistical analysis of the Harvard Step Test and the McCloy Endurance Ratio, shows little difference in the means between varsity and non-varsity with no statistical significance as indicated in tables 9 and 10.

Tables 20 and 23 concerning the analysis of high and low leg length scores on the post-pubescent level between varsity and non-varsity, indicates a high difference between the means with both groups favoring high leg length. The critical ratios are statistically significant in both tables.

Tables 21 and 24 concerning the analysis of Harvard Step Test scores on high and low leg length, indicates a higher difference in the means in the table 24 of the varsity as compared to the table 21 of the non-varsity group with both varsity and non-varsity groups favoring high leg length. The critical ratio of both groups are statistically insignificant at the 1% level.

Tables 22 and 25, concerning the analysis of the McCloy Endurance Ratio scores on the high and low leg length, indicates little difference between the means when both groups are compared.

The varsity group favors the low leg length and the non-

varsity group favors the high leg length. The critical ratios of both groups are statistically insignificant at the 1% level.

The differentiation between varsity and non-varsity classification in the study was made on the basis of participation or non-participation in the school's varsity sports during the period in which the testing took place.

A planned endurance training program for varsity classification may have given greater significance to the differentiation of non-varsity and varsity grouping in relation to eliminating the factor of outside physical activities in which non-varsity boys may be participating which can make the classification questionable.

A planned endurance training program for all subjects could have made the state of training constant, but this is difficult to do in actual school situation because of interference with the program of physical education.

SUMMARY OF STATISTICAL DATA

Comparisons between the three maturity levels on the Harvard Step Test and the McCloy Endurance Ratio. Tables 3 and 4 indicate no difference exists in the means between the pre-pubescent and pubescent levels in both endurance tests.

Tables 5 and 6 indicate a difference in the means favoring post-pubescence over pre-pubescence in both endurance tests. The critical ratios of both tables were found to be statistically insignificant at the 1% level.

Tables 7 and 8 indicate a difference in the means favoring post-pubescence over pubescence in both endurance tests. The levels of significance were very small, being statistically insignificant at the 1% level.

Comparisons between the varsity and non-varsity groups in the post-pubescent level for both endurance tests. Table 9 indicates a difference in means favoring the non-varsity group over the varsity for the Harvard Step Test. The level of significance is very small, being statistically insignificant at the 1% level.

Table 10 indicates a difference in means favoring the varsity group over the non-varsity for the McCloy Endurance Ratio. The level of significance is statistically insignificant at the 1% level.

Leg Length Morphology (Non-Varsity). Table 11 indicates that within the pre-pubescent level the difference in means favors high leg length over low leg length which is statistically significant at the 1% level.

Table 14 indicates that between the post-pubescent and pre-pubescent levels, high leg length of post pubescent is favored high leg length of pre-pubescence which is statistically insignificant at the 1% level.

Table 15 indicates that between the post-pubescent and pre-pubescent levels, low leg length of post-pubescent is favored over low leg length of pre-pubescence. The critical ratio of 4.56 is statistically significant at the 1% level.

Table 20 indicates that the difference in means favors high leg length over low leg length within the post-pubescent level. The difference is statistically significant at the 1% level.

Leg Length Morphology (Varsity). Table 23 indicates that the difference in means favors high leg length over low leg length within the post-pubescent level. The difference is statistically significant at the 1% level.

Table 26 indicates that the difference in the means favors high leg length over low leg length within the post-pubescent level (varsity and non-varsity combined). The difference is statistically significant at the 1% level.

Analysis of leg length influence on performance scores of the Harvard Step Test and McCloy Endurance Ratio. Tables 12 and

13 indicate that on the pre-pubescent level, leg length influences performances on the Harvard Step Test, but not on the McCloy Endurance Ratio. The critical ratios are not statistically significant at the 1% level.

Tables 16 and 19 indicate that the difference in the means for high leg length between the pre-pubescent and post-pubescent levels, in comparing both endurance tests, favors post-pubescence. The critical ratios are not statistically significant at the 1% level.

Tables 17 and 18 indicate that the difference in the means for low leg length between the pre-pubescent and post-pubescent levels, in comparing both endurance tests, favors post-pubescence in the Harvard Step Test, and pre-pubescence in the McCloy Endurance Ratio. The critical ratios are not statistically significant at the 1% level.

Tables 21 and 22 indicate that the difference of the means, in comparing both endurance test on the post-pubescent level (non-varsity), favors high leg length over low leg length. The critical ratios are not statistically significant at the 1% level.

Tables 24 and 25 indicate that the difference of the means, in comparing both endurance tests on the post-pubescent level (varsity), favors high leg length over low leg length for the Harvard Step Test scores. For the McCloy Endurance Ratio scores, the difference in the means favors low leg length over high leg length. The critical ratios are not statistically

significant at the 1% level.

Tables 27 and 28 indicate the difference in the means, in comparing both endurance tests on the post-pubescent level (varsity and non-varsity combined), favors high leg length over low leg length. The critical ratios are statistically insignificant at the 1% level.

COMPARISON AND INTERPRETATION OF STATISTICAL RESULTS WITH PREVIOUS RESEARCH STUDIES

McCloy's[1] ratio as a criterion of endurance was correlated against the Harvard Step Test in the pre-pubescent and post-pubescent levels. The correlation in the pre-pubescent group was .064. The correlation in the post-pubescent group was -.115.

The correlation between both tests combining all maturity levels was .044.

Bell's[2] study, reported a correlation of .52 between the pulse ratio test and McCloy's[3] Ratio, using an experiential group of 51 track men and five others.

Factors which may account for the differences in correlations may be, (1) advanced physiological age of subjects in Bell's[4] study, (2) a higher state of training of subjects in

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[1]C. H. McCloy, op. cit., p. 248.

[2]T. B. Bell, op. cit., p. 229.

[3]C. H. McCloy, op. cit., p. 248.

[4]T. B. Bell, op. cit., p. 229.

Bell's[1] study, and (3) differences in such factors as judgment of pace, running skill and will power. Errors of measurement, or the difficulty of standardization of testing condition may be influencing factors.

The low positive correlation of .064 on the pre-pubescent level as compared to the negative correlation of -.115 on the post-pubescent level may be influenced by the number of cases used, (44 pre-pubescent, 111 post-pubescent).

Cureton,[2] et al., studies of 117 men students in physical education classes correlated the step test with a number of endurance tests. The following conclusions were drawn from correlations of the step test with running tests:

1. Step Test mile run (.310)
2. Step Test 300 yard run (.272)
3. Step Test 100 yard dash (.185)
4. Step Test 1000 yard run (.132)

The conclusion was that the five-minute Step Test on a fifteen-inch bench is not a good test for indicating the kind of muscular efficiency wanted by the military services. There were 27 endurance tests used in physical fitness testing correlated with the Step Test.

With experienced and well trained men, the five-minute

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[1] Ibid., p. 229

[2] T. K. Cureton, et al., "Endurance of Young Men," Society of Research in Child Development, National Research Council, 1945, p. 284.

Step Test on a fifteen-inch bench, correlated .429 with the mile time on the basis of single tests.

Hodgson's[1] work indicated that the Step Test correlated low with running tests (.05).

The pre-pubescent correlation of (.064) indicates that the two endurance tests do not measure the same qualities.

The post-pubescent correlation of (-.115) indicates that the two endurance tests have a low negative correlation.

The influence of one or of more than one of the variables may be a significant factor in the size and relationship of the two variables.

In comparing the size and relationship of the correlations in this study with research findings reported previously, the factors of age difference, state of training, different conditions of testing and tests would make a real comparison between the studies difficult and of questionable value. In general, it can be stated that the relationship between the variables of the Harvard Step Test and the McCloy Endurance Ratio in this study and the previous studies do not give an indication of vigorous validation.

The variability of heart rate as measured by the standard deviation of the Harvard Step Test for the three maturity levels of tables 3, 4, and 5 indicated that: (1) pubescents are more

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[1]Hodgson, P. "Studies in the Physiology of Activity, I, On Certain Reactions of College Women to Measured Activity," Research Quarterly, 7: March, 1936, p. 3.

variable in their response than the other two groups, and (2) there is a greater difference in the comparison of pre-pubescent to pubescent (3.1) than in the comparison of pubescent to post-pubescent (1.3).

Brock's[1] study of heart rate in the vertical and horizontal positions indicated that, (1) variability was greater in pubescents and post-pubescents than in pre-pubescents in both vertical and horizontal positions, and (2) pubescent are more unevenly distributed than the other two groups.

It may be that, differences in variability in heart rate in Brock's[2] study for vertical and horizontal positions as compared to the variability of heart rate on the Harvard Step Test in this study, when compared, is due to the psychological apprehension factor encountered during testing in Brock's study. Brouha and Heath[3] states that initial pulse rates were found to be markedly affected by apprehension.

The statistical results of the correlations between the Harvard Step Test and body surface area are:

1. pre-pubescent .025
2. post-pubescent .082
3. combined maturity levels .080

The correlations between Endurance Ratio and body surface

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[1]J. P. Brock, op. cit., p. 44.

[2]Ibid., p. 44.

[3]L. Brouha, and C. W. Heath, op. cit., pp. 473-477.

area are:

1. pre-pubescent .054
2. post-pubescent .225
3. combined maturity levels .157

Brouha and Gallagher's[1] study having subjects using a bicycle ergometer at the rate of twenty miles per hour against a friction load of five pounds for five minutes indicated that: (1) test conditions were too severe for most of the smaller subjects and this was apparently affected more by size than age or fitness, (2) indication that physical efficiency increases in relation to size rather than to age.

The correlations in this study are apparently low, the post-pubescents have a slightly higher correlation in the Harvard Step Test body surface correlation than the pre-pubescent. The combined maturity levels correlation between Harvard Step Test and body surface area shows an increase over the pre-pubescent correlation, but does not show an increase over the post-pubescent level. The results of comparisons applying to the McCloy Endurance Ratio body surface area correlation are similar. The correlations between Endurance Index and body surface area are higher when compared to the correlations of the Harvard Step Test body surface area.

The variable, according to the correlation comparisons, of body surface area indicates some influence in the relationship

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[1] L. Brouha and J. R. Gallagher op. cit., pp. 657-670.

between the McCloy Endurance Ratio and body surface area, most significant in the post-pubescent stage.

The comparison of the correlations between the two maturity levels and the combination of pre-pubescent and post-pubescent levels indicates that the post-pubescent level seems to have the highest size and relationship. The inclusion of pubescent scores in the combined maturity levels correlation, may be an influencing factor.

The results may have some significance with the conclusion of Brouha and Gallagher's[1] study in that, "physical efficiency increases in relation to size rather than to age."

In relation to physiological age, (pre-pubescent and post-pubescent), the intercorrelations of variables do not indicate a significant change as age increases from pre-pubescence to post-pubescence except in (1) the correlations between the Harvard Step Test and Endurance Index of pre-pubescent and of post-pubescence, (pre-pubescent, .064, post-pubescent, -.115); (2) correlations between Endurance Index and leg length (pre-pubescent, -.213, post-pubescent, .127); (3) correlations between Endurance Index and body surface area,(pre-pubescent, .054, post-pubescent, .225); correlations between Endurance Index and weight, (pre-pubescent, .019, post-pubescent, .248); and (5) correlations between Endurance Index and height,(pre-pubescence, .05, post-pubescent .194).

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[1] Ibid., pp. 657-670.

In comparison, Dane's[1] study of the McCurdy-Larson Organic Efficiency Test drew the following conclusions:

1. A gradual change takes place in the physiological variables as age increases from pre-pubescence to post-pubescence.

2. The least change is noticed between the pre-pubescent and pubescent, and the greatest change between the pre-pubescent and post-pubescent.

3. Post-pubescent boys are highly superior, pre-pubescent boys are least efficient in ciruclatory respiratory function.

The physiological variables of the McCurdy-Larson Organic Efficiency Test are: (1) sitting diastolic blood pressure, (2) breath holding, twenty seconds after a standard stair climbing exercise, (3) difference between standing normal pulse rate and pulse rate two minutes after exercise, (4) standing pulse pressure, and (5) vital capacity.

Dane's[2] study does not indicate whether or not the subjects were classified as non-athlete, athletic or a combination of both.

In the intercorrelations of this study the pre-pubescent level was non-varsity and the post-pubescent level was a combination of varsity and non-varsity. The correlations do not indicate that post-pubescent boys are highly superior to pre-pubescent boys in relation to circulatory-respiratory function as pointed out in Dane's[3] study, although the variables of body

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[1] C. W. Dane, op. cit., pp. 98-112.

[2] Ibid., pp. 98-112.

[3] Ibid., pp. 98-112.

surface area, weight and height of post-pubescence, indicate a relative increase over those of pre-pubescence.

Elbel's[1] study drew as one of its conclusions that: "the coefficient of correlation between body weight and increased pulse rate due to exercise is insignificant."

The intercorrelations of body weight and the Harvard Step Test and McCloy Endurance Ratio indicate:

1. A correlation of -.035 between the Harvard Step Test and body weight (pre-pubescence)

2. A correlation of -.019 between the Endurance Index and body weight (pre-pubescent)

3. A correlation of .095 between the Harvard Step Test and body weight (post-pubescence)

4. A correlation of .248 between the Endurance Index and body weight (post-pubescence)

The intercorrelations of combined maturity levels indicate (1) a correlation of .045 between the Harvard Step Test and body weight, and (2) a correlation of .191 between the Endurance Index and body weight.

The correlations between the endurance tests and body weight on the pre-pubescent level indicate a low negative relationship.

The correlation between the endurance tests and body weight on the post-pubescent level indicate a positive relationship with the correlation between the McCloy Endurance Ratio and

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[1]E. R. Elbel, op. cit., p. 222.

body weight giving a higher reading (.248) as compared to the Harvard Step Test, body weight correlation (.095).

A comparison of the correlations of the combined maturity levels indicate, a higher positive relationship existing in the correlation between the McCloy Endurance Index and body weight (.191) as compared to the Harvard Step Test, body weight correlation of .045.

The correlation of .248 between the Endurance Ratio and body weight although low, does give an indication of some significance in comparison with the other statistical results.

Bookwalter's[1] study of the Harvard Step Test, administered to over one thousand ASTP students, indicated the following intercorrelations:

1.	Harvard Step Test	height	(-.092)
2.	Harvard Step Test	weight	(.086)
3.	Harvard Step Test	300 yard dash	(.037)
4.	Harvard Step Test	Army Test	(.035)
5.	Harvard Step Test	100 yard pick-a-back	(.041)
6.	Harvard Step Test	age	(-.056)

The indication from these correlations is:

1. The Harvard Step Test is insignificantly related to all factors
2. Of the items correlated, there is slightly more relationship (inversely) between the Harvard Step Test and height than between the other items.
3. There appears to be a low negative relationship between the Step Test and age, height, and the one hundred yard pick-a-back.

The intercorrelations of this study in comparison to Bookwalter's are:

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[1]K. A. Bookwalter, op. cit., p. 55.

1. Harvard Step Test height (.070) pre-pubescent
2. Harvard Step Test height (.004) post-pubescent
3. Harvard Step Test height (.052) combined maturity levels
4. Harvard Step Test weight (-.035) pre-pubescent
5. Harvard Step Test weight (.095) post-pubescent
6. Harvard Step Test weight (.045) combined maturity levels
7. Harvard Step Test Endurance Ratio (.064) pre-pubescent
8. Harvard Step Test Endurance Ratio (-.115) post-pubescent
9. Harvard Step Test Endurance Ratio (-.044) maturity levels combined

These correlations give an indication that:

1. The Step Test is insignificantly related to all the variables
2. Of all the items correlated, there is a higher relationship (inversely) between the Harvard Step Test, and the McCloy Endurance Ratio on the post-pubescent level than between the other items.

A comparison of the Bookwalter study and the statistical results of the correlation of this study in relation to the variables correlated, indicates a similarity of intercorrelation results either of low positive or negative relationships.

CHAPTER IV

SUMMARY AND CONCLUSIONS

Summary of the study. The findings of this study pertains more to pure research as a basis for further research work, in which findings, if significant, may indicate the possibility of being applied to practical problems that may be encountered in the area of cardiovascular testing.

The purpose of this study was to indicate whether or not the two endurance tests correlated moderately highly as stated in the hypothesis. If the results did not indicate a moderately high correlation, then the influences of the variables of leg length, height, weight, physiological age, and body surface area would be statistically analyzed and interpreted for significance.

The influence of the variables on the McCloy Endurance Ratio were also statistically analyzed and were compared against the statistical analysis results of the influences of the variables on the performance scores of the Harvard Step Test.

The influence of the variable of chronological age was not statistically analyzed due to the extent of the statistical work covered, and the time element allowed to complete the study.

The study was delimited to junior high and senior high school boys classified on the basis of physiological age according to the physiological age grouping as set forth in Crampton's[1] criteria. The technique of timing at the ten-yard

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[1]H. Dimock, op. cit., p. 419.

mark for the McCloy Endurance Index was used to hold constant the factor of starting skill for all subjects.

The Weston schools of Weston, Massachusetts, and the Concord schools of Concord, Massachusetts were selected for the collection of the data. The physical education programs of both schools were similar except that the Concord schools had classes four times a week, and the Weston schools had classes two times a week. The greater part of the testing was completed within two weeks, most of the subjects being tested at the Concord schools which had a greater number of boys than the Weston schools.

The standardization of testing conditions was adhered to as closely as possible, the results were satisfactory in concern to the conditions under which the study was made. However, it must be emphasized that standardization procedures should be controlled more closely than was possible under the conditions of which this study was made, to eliminate factors which would negatively influence the validity and reliability of results. The elements of standardization to be concerned with are: (1) administering both tests at a similar time of day on successive days for all subjects; (2) taking all measurements of variables a day or two before testing, for all subjects; (3) varsity and non-varsity grouping based upon a procedure which would make the differentiation valid and not open to question because of outside influences; and (4) a sufficient

recovery time allowed between runs on the McCloy Endurance Ratio, constant for all subjects.

The study was also limited to the extent that the number of cases for the pubescent level was low which disallowed adequate statistical analysis within and in comparison with the other maturity levels.

To give a greater statistical emphasis for significance of findings, it would be more appropriate to collect data for a minimum of 100 cases to a maximum of 200 cases for each level, to give a better picture of the influence of the variable of leg length on performance scores of the Harvard Step Test and McCloy Endurance Ratio, and the correlations of endurance tests and variables.

Statistical tabulations were made from 44 cases for the pre-pubescent level, 18 cases for the pubescent level, 111 cases for the post-pubescent level, 20 cases of high leg length and 20 cases for low leg length for the post-pubescent level, 15 cases for high leg length and 15 cases of low leg length for the pre-pubescent level.

The evidence of statistical significance or non-significance of the findings on the influence of leg length upon performance scores on the endurance tests, is to be found in the difference of means for the pre-pubescent and post-pubescent levels. The significance of the differences between means for the maturity levels was found by computing the critical ratios between them.

The evidence of negative or positive relationships between the variables in the study is to be found in the zero order correlations.

The following data present a summary of the statistical results of the study:

Comparisons between the three maturity levels for the Harvard Step Test and McCloy Endurance Ratio.

a. There is no difference in the means between the pre-pubescent and pubescent levels for both endurance tests.

b. There is a difference in the means of 1.5 in favor of the post-pubescent level over the pre-pubescent level for the Harvard Step Test. The critical ratio is 1.12 which is statistically insignificant at the 1% level.

c. There is a difference in the means of .08 in favor of the post-pubescent level over the pre-pubescent level for the McCloy Endurance Ratio. The critical ratio is 1.11 which is statistically insignificant at the 1% level.

d. There is a difference in the means of 1.5 favoring the post-pubescent level over the pubescent level for the Harvard Step Test. The critical ratio is .588 which is statistically insignificant at the 1% level.

e. There is a difference in the means of.12 favoring the post-pubescent level over the pubescent level for the McCloy Endurance Ratio. The critical ratio is .258 which is statistically insignificant at the 1% level.

Statistical Analysis of the Varsity and Non-Varsity groups on the post-pubescent level for both Endurance Tests.

Za. A difference in the means of 1.1 favors the non-varsity group over the varsity group on the post-pubescent level for the Harvard Step Test. The critical ratio is statistically insignificant at the 1% level.

b. There is a difference in the means of .12 favoring the varsity group over the non-varsity group on the post-pubescent level for the McCloy Endurance Ratio. The critical ratio is statistically insignificant at the 1% level.

Leg Length Morphology Within the Pre-pubescent level (Non-Varsity).

The difference in means is 14.9 in favor of the high leg length over low leg length. The critical ratio is 4.85 which is statistically significant at the 1% level.

Leg Length Morphology Within the Post-pubescent level (Non-Varsity).

The difference in means is 11.84 in favor of high leg length over low leg length. The critical ratio is 12.2 which is statistically significant at the 1% level.

Comparison of High Leg Length Morphology between the Pre-pubescent and Post-pubescent levels (Non-Varsity).

The difference in means is 3.1 in favor of the post-pubescent level. The critical ratio is 1.06 which is statistically insignificant at the 1% level.

Comparison of Low Leg Length Morphology between the Pre-

pubescent and Post-pubescent levels (Non-Varsity).

The difference in the means is 6.16 in favor of the post-pubescent level. The critical ratio is 4.56 which is statistically insignificant at the 1% level.

Leg Length Morphology within the Post-pubescent level (Varsity).

The difference in the means is 10.35 favoring the high leg length over the low leg length. The critical ratio is 5.33 which is statistically significant at the 1% level.

Leg Length Morphology within the Post-pubescent level (Varsity and Non-Varsity Combined).

The difference in the means is 16.5 favoring high leg length over low leg length. The critical ratio is 10 which is statistically significant at the 1% level.

Analysis of Leg Length Morphology to indicate its influence on performance scores of the Harvard Step Test and the McCloy Endurance Ratio.

Pre-Pubescence (Non-Varsity).

a. There is a difference in the means of 1.07 in favor of high leg length over low leg length for the Harvard Step Test scores. The critical ratio is .399 which is statistically insignificant at the 1% level.

a. There is a difference in the means of .29 in favor of low leg length over high leg length for the McCloy Endurance Ratio. The critical ratio is 1.90 which is statistically insignificant on the 1% level.

Comparison between Pre-pubescent and Post-pubescent levels (Non-Varsity).

a. There is a difference in the means of 3.2 favoring post-pubescence high leg length over pre-pubescence high leg length for the Harvard Step Test scores. The critical ratio is 1.07 which is statistically insignificant at the 1% level.

b. There is a difference in the means of .16 in favor of low leg length over high leg length for the McCloy Endurance Ratio. The critical ratio is 1.22 which is statistically insignificant at the 1% level.

Post-pubescence (Non-Varsity).

a. There is a difference in the means of .75 favoring high leg length over low leg length for the Harvard Step Test scores. The critical ratio is .242 which is statistically insignificant at the 1% level.

b. There is a difference in the means of .14 favoring high leg length over low leg length for the McCloy Endurance Ratio scores. The critical ratio is .909 which is statistically insignificant at the 1% level.

Post-pubescence (Varsity).

a. There is a difference in the means of 3.60 favoring high leg length over low leg length for the Harvard Step Test scores. The critical ratio is 1.44 which is statistically insignificant at the 1% level.

b. There is a difference in the means of .01 favoring low leg length over high leg length for the McCloy Endurance

Ratio scores. The critical ratio is .0769 which is statistically insignificant at the 1% level.

Post-pubescent (Varsity and Non-Varsity Combined).

a. There is a difference in the means of .30 favoring high leg length over low leg length for the Harvard Step Test scores. The critical ratio is .114 which is statistically insignificant at the 1% level.

b. There is a difference in the means of .20 favoring high leg length over low leg length for the McCloy Endurance Ratio scores. The critical ratio is 1.39 being statistically insignificant at the 1% level.

The evidence of the intercorrelations between the Endurance Tests and between the Endurance Tests and the variables presents the following results

The Harvard Step Test has a low positive relationship with the McCloy Endurance Ratio on the pre-pubescent level (.064).

The Harvard Step Test has a low negative relationship with the McCloy Endurance Ratio on the post-pubescent level (-.115).

The Harvard Step Test has low positive relationships with the following variables on the pre-pubescent level: height (.070), body surface area (.025), and leg length (.050).

The Harvard Step Test has a low negative relationship with weight (-.035) on the pre-pubescent level.

The McCloy Endurance Ratio has a low positive relationship

with height (.05) and body surface area (.054) on the pre-pubescent level.

The McCloy Endurance Ratio has a negative relationship with weight (-.019) and leg length (-.213) on the pre-pubescent level.

The Harvard Step Test has a low positive relationship with the following variables on the post-pubescent level: height (.0041), leg length (.060), weight (.095), and body surface area (.0824).

The McCloy Endurance Ratio has a higher positive relationship with the following variables in comparison to the Harvard Step Test, on the post-pubescent level: height (.194), weight (.248), leg length (.127), and body surface area (.225).

The evidence of the intercorrelations between the Endurance Tests, and between the Endurance Tests and the variables for the combined maturity levels of pre-pubescent, pubescent, and post-pubescent, presents the following results:

The Harvard Step Test has a low negative relationship with the McCloy Endurance Ratio, (-.044).

The Harvard Step Test has a low positive relationship with the following variables: leg length (.085), weight (.045), body surface area (.080), and height (.052).

The McCloy Endurance Ratio has a low positive relationship with the variable of leg length (.047), and height (.107).

The McCloy Endurance Ratio has a low positive relationship with the variables of weight (.191) and body surface area

(.157). These correlations have the highest size in comparison with the other intercorrelations between the endurance tests and the variables.

Conclusions of the Study. The direct correlation of the Harvard Step Test against the McCloy Endurance Index indicated the following results: (1) a low positive correlation for the pre-pubescent level, (2) a low negative correlation for the post-pubescent level, and (3) a low positive correlation for the combined maturity levels.

The analysis of leg length indicates that there is a real difference in leg length within and between the maturity levels of pre-pubescent and post-pubescent. The post-pubescent level has a higher leg length than the pre-pubescent level.

The analysis of the Harvard Step Test and the McCloy Endurance Ratio scores to indicate if leg length is an influencing factor in the scores of the tests showed that although there is some indication of high leg length influence on the performance scores of the tests, the findings are statistically insignificant.

Other Conclusions that may be drawn from the Study.

1. The Harvard Step Test and the McCloy Endurance Ratio have a low correlation with the variables of height, weight, body surface area on the pre-pubescent level, with the exception of leg length which although low, give a higher size in comparison with the other variables.

2. The Harvard Step Test and the McCloy Endurance Ratio have low correlations with all the variables on the post-pubescent level, but the McCloy Endurance Ratio showed greater size correlations for the variables of body surface area, weight, height, and leg length in comparison with all the other correlations for pre-pubescence and post-pubescence.

3. The Harvard Step Test and the McCloy Endurance Ratio have low correlations with all the variables for the combined maturity levels. The McCloy Endurance Ratio correlations with height, weight, and body surface area had the highest size.

4. The non-varsity group had a higher mean gain than the varsity for the Harvard Step Test on the post-pubescent level. The finding was statistically insignificant.

The varsity group had a higher mean gain than the non-varsity for the McCloy Endurance Ratio on the post-pubescent level. The finding was statistically insignificant.

5. The evidence presented in the previous research work indicates that the Harvard Step Test and the McCloy Endurance Ratio do not correlate highly as measures of endurance. The evidence also indicates that the influences of variables of height, weight are negligible while that of body surface area may have some influence. There was no evidence presented in reference to the variable, leg length. Lastly, the previous research work gives some indication that post-pubescent boys are superior to pre-pubescent boys in physiological effort.

6. The findings in this study in comparison to previous

research work indicate that the endurance tests fail to show moderately high correlations.

7. The post-pubescent level did not show evidence of high superiority over the pre-pubescent level in physiological effectiveness.

8. The post-pubescent level did show some superiority for certain variables (height, weight, body surface area), with the McCloy Endurance Ratio, and for the variable of leg length. The findings for the variable of leg length were not statistically significant.

Recommendations for further Study.

1. Statistical analysis of the variables of height, weight and body surface area to indicate if these variables have influence on performance scores of the Endurance Tests.

2. Zero order correlations among (a) height and chronological age, (b) Harvard Step Test and chronological age, and (c) McCloy Endurance Index and chronological age for all subjects.

3. Zero order correlation of height and chronological age at which subjects become post-pubescent.

4. Partial correlation of body surface area and the McCloy Endurance Ratio, holding age constant.

5. Partial correlation of weight, and the McCloy Endurance Ratio, holding age constant.

6. Repeat of the study to include:

   a. Equal number of cases for all maturity levels

   b. A greater number of cases to statistically analyze the influence of leg length upon performance scores of the endurance tests

   c. A planned endurance program to make the state of training constant for all subjects.

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APPENDIX

Name _____ Control _____

Age _____ Exp. _____

Physiological Classification

Pre. Pub. _____
Pub. _____
Post. Pub. _____

Anthropometric Data Date _____

WEIGHT _____

HEIGHT _____

Sitting HEIGHT _____

Body Surface Area _____

Cause of Elimination from Test

1. Physical exercise during day
2. Loss of sleep night before
3. Cold, sore throat, etc.
4. Stomach upset
5. Fatigue
6. Excitement for any reason
7. Doubtful physical age
8. Mental anxiety, nervousness

TEST SCORES Date _____

Step Test

1st pulse recup. count _____

2nd pulse recup. count _____

3rd pulse recup. count _____

Score _____

Date _____

McCloy End. Index

Time

220 yd. _____

60 yd. _____

Score _____

FORMULAS USED IN THE STATISTICAL ANALYSIS OF THE DATA

1. Mean $\frac{\Sigma fx}{N}$ ci

2. Standard Deviation $ci \sqrt{\frac{\Sigma fx^2}{N} - c^2}$

3. Standard Error of the Mean $\frac{SD}{\sqrt{N}}$

4. Standard Error of Difference $\sqrt{SEM_1^2 + SEM_2^2}$

5. Critical Ratio of Mean $\frac{DIFF_{M_1 - M_2}}{SE_{DIFF_{M_1 - M_2}}}$

6. Zero Order Correlation — Durost-Walker Correlation Chart