The Effect of Wrestling Training and Required Physical Education Upon the Physical Condition of College Students as Determined by the Rogers Strength Test and the Harvard Step Test

Thomas Eugene Neuberger

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THE EFFECT OF WRESTLING TRAINING AND REQUIRED PHYSICAL EDUCATION
UPON THE PHYSICAL CONDITION OF COLLEGE STUDENTS AS DETERMINED BY
THE ROGERS STRENGTH TEST AND THE HARVARD STEP TEST

By

Thomas Eugene Neuberger

A thesis submitted in partial fulfillment of the requirements for the degree of Master of Science in the Department of Physical Education in the Division of Applied Arts and Sciences of South Dakota State College

May, 1955
THE EFFECT OF WRESTLING TRAINING AND REQUIRED PHYSICAL EDUCATION
UPON THE PHYSICAL CONDITION OF COLLEGE STUDENTS AS DETERMINED BY
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This thesis is approved as a creditable, independent investigation
by a candidate for the degree, Master of Science, and acceptable
as meeting the thesis requirements for this degree; but without
implying that the conclusions reached by the candidate are neces­
sarily the conclusions of the major department.
ACKNOWLEDGEMENTS

The writer wishes to express his most sincere appreciation to Mr. R. B. Frost for his able supervision of this study, and for his valuable suggestions and assistance in carrying out this research.

Expressions of appreciation are also due to the other faculty members and the many students whose aid and co-operation made this study possible.
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CHAPTER 1

INTRODUCTION

The improvement of athletics and physical education can only be brought about when the participating individuals strive to attain their optimum physical condition. There are numerous phases of physical conditioning with which we are confronted in the attainment of total physical condition. Some of the many functions of the human organism with which we are concerned when striving for optimum physical condition are: respiratory, cardiovascular, nervous, and muscular. A student of physiology understands that all functions of the human body are equally vital to the maintenance of life and health. This statement is undoubtedly true. If we look at the field of physical education and athletics we see that certain functions of the body are more important to the attainment of the objectives than are others. For example, an artist would place more of a premium on a conditioned nervous system than a conditioned cardiovascular system capable of pumping great quantities of blood through the body. It would seem that the athlete and physical education student would need most of all an outstanding cardiovascular and muscular system to approach the goals set up for them. This thesis has, therefore, been set up to study methods of improving these functions of the human body through various types and degrees of training.
PROBLEM

This study describes some of the many activities and procedures that could be used to develop and improve the muscular and cardiovascular systems of an individual. The purpose of this study is to ascertain the degree and speed with which wrestler training will develop these areas. Throughout the report other sports and physical education activities enter the picture and help to recognize the cause of a specific physiological phenomenon. However, it must be kept in mind that the major conclusions will be drawn from the effects of wrestling. To study wrestling as a means of improving and developing strength and circulation is the major purpose of this thesis.
CHAPTER II

RELATED LITERATURE

The Encyclopaedia Britannica Library Research Service\(^1\) summarizes the influence of athletic training on strength and cardiovascular improvement as follows:

Exercise modifies the functions of the human organism. The amount of the modification is in proportion (to the limits of heredity) to the frequency, duration, and intensity of individual effort. Great demands must be placed on circulation and respiration before any marked changes will result, and some circulatory and respiratory functions are changed more than others. The modification as a result of training or exercise remains only as long as training continues. When training ceases, the functions of circulation and respiration are reduced to a lower level of activity; therefore one is not able to perform as long as previously in activity which places demands on circulation and respiration.

Riedman\(^2\) indicated the numerous adaptations which resulted in the body of the trained man that are less efficient in the untrained man. The trained individual differs from the untrained in oxygen consumption, pulse rate, stroke volume, blood pressure, blood lactate, and the return of pulse rate and blood pressure to normal as the following outline shows.

1. Easy work that both can sustain in a steady state:

   \[
   \begin{array}{c|c|c|c|c|c}
   & \text{Fit Man} & \text{Unfit Man} \\
   \hline
   \text{(a) Oxygen consumption.} & \text{Lower} & \text{Higher} \\
   \text{(b) Pulse rate during work.} & \text{Lower} & \text{Higher} \\
   \end{array}
   \]

\(^1\)Encyclopaedia Britannica Library Research Service, 425 North Michigan Avenue, Chicago 11, Illinois.

(Cont'd.)

<table>
<thead>
<tr>
<th>(c) Stroke volume during work.</th>
<th>Fit Man</th>
<th>Unfit Man</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Larger</td>
<td>Smaller</td>
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<tr>
<td>(d) Blood pressure during work.</td>
<td>Lower</td>
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<tr>
<td>(e) Return of blood pressure to normal after work.</td>
<td>Faster</td>
<td>Slower</td>
</tr>
<tr>
<td>(f) Return of pulse rate to resting value after work.</td>
<td>Faster</td>
<td>Slower</td>
</tr>
</tbody>
</table>

2. Exhausting work that neither can sustain in a steady state:

<table>
<thead>
<tr>
<th>(a) Maximum oxygen consumption.</th>
<th>Fit Man</th>
<th>Unfit Man</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Higher</td>
<td>Lower</td>
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<tr>
<td>(b) Maximum pulse rate during work.</td>
<td>Lower</td>
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<tr>
<td>(c) Stroke volume.</td>
<td>Larger</td>
<td>Smaller</td>
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<tr>
<td>(d) Duration of work before exhaustion.</td>
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<td>Faster</td>
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</tr>
<tr>
<td>(f) Return of pulse rate to resting level after work.</td>
<td>Faster</td>
<td>Slower</td>
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</tbody>
</table>

In addition, vital capacity increases with training, minute volume becomes larger, and mechanical efficiency improves, which increases the effective utilization of energy or reduces cost.

STRENGTH TESTING

Rogers$^3$ sufficiently states the opinion of physical educators and physiologists in one of his many reported studies when he writes concerning the necessity of strength in the human body.

The positive and very high relation of muscular strength to general health, physical fitness, or "capacity for activity" can hardly be questioned. With no strength there can be no physical activity; moreover, when muscular strength is low, all other life functions are handicapped. One can hardly see as much, hear as much, meet as many people, or contribute as much to social life when one is continually fatigued by the most

---

necessary activities of life-eating, digestion, attention to environment, and the physical movements incident upon travel from one group of surroundings to another. The relation of the effective condition of voluntary muscle tissue to other organic conditions is just beginning to be recognized; but experiences are multiplied which reveal, beyond paradventure, the truth of the following rule: Practically every change in the condition or functioning of the vital organs has a corresponding change in the condition or functioning of voluntary muscle.

Clarke reported a comparative analysis of a group of commonly used objective strength tests. From the conclusions of this study a very good explanation of strength tests can be derived. Muscular strength tests and test items are validated according to a criterion measure of general motor ability, and a criterion measure of physical fitness. In both instances, muscular strength is a major component. The correlations with a rather complete index of general motor ability are from .85 to .90. In instances where a physical fitness criterion of long, hard, sustained muscular work and endurance is used, muscular strength tests are always significant.

A review of the history of strength testing reveals the interesting fact that measures of strength have been employed to meet many divergent needs. McCloy in a publication points out that strength testing has two important uses in physical education and athletics; first, as an index of health or general physical condition, and, second, as a predictor of potential motor ability.

Strength testing was begun in 1888 when D. A. Sargent developed the

---


The Intercollegiate Strength Test was used extensively in the early 1900's, but lost prominence at the onset of world conditions relating to World War I. Following World War I, Rogers revised the test and in 1931 Mc Cloug published a report which refined the computations and started a series of investigations designed to validate this battery of strength measurements to specific needs.

Since the origin of strength testing the question has always arisen as to what part of the body should be measured to get a true picture of total body strength. Some tests include measurement of one muscle group while another will leave it out. There does not seem to be any standardized battery of tests which should be included in a strength test. Wendler made a study in this area. He concluded the following:

1. The sum of the strengths of four muscle groups—the thigh flexors, the leg extensors, the arm flexors, and the pectoralis major—gives a highly reliable prediction of total strength of men.

2. The deltoids and hand flexors plus the four groups for men when properly combined will predict total strength of woman with approximately the same degree of reliability as the men's battery does for men.

3. The above batteries are almost as valuable for the prediction of total strength as the entire Intercollegiate Strength Test.

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8C. R. Mc Cloug, "A New Method of Scoring, Chinning and Dipping," Research Quarterly, 4:3-1-, December, 1931.

Test and have the added advantage of requiring no expensive apparatus.

Hubbard and Mathews\textsuperscript{10}, also did a study in this area. Their study was only concerned with leg strength. They did not conclude with evidence supporting any particular muscle group which offered the best criterion of total strength, but did report that a measure of leg strength with a leg dynamometer was significantly more reliable when a belt was used.

**Clarke Strength Test:**\textsuperscript{11} The Clarke Strength Test employs the tensiometer, generally used to test the tension of aircraft cables, for measuring the strength of muscle groups. Measurement can vary from five to 300 pounds. The anatomical position of the joint for the application of pulling force is specified for each test in the strength measurement sequence. This adjustment attempts to eliminate the compensation action of muscles. Strength tests may be applied to the joint of the wrist, elbow, shoulder, hip, knee, and ankle. A number of muscle groups are measured in each position. Test reliabilities are high.

**Wendler's Total Strength Index:**\textsuperscript{12} Wendler designed a strength index to analyze statistically a large battery of strength tests to determine for each sex the muscle groups that are most valuable in predicting total strength. The universal dynamometer was the instrument used to measure 47 different muscle groups. The criterion of strength was the sum of these

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\textsuperscript{12} Wendler, \textit{loc. cit.}
7 strength measures. Wendler improvised a short battery which gave a high correlation with the original 47 tests. The short battery included: (1) the thigh extensors; (2) the leg extensors; (3) the pectoralis major; (4) the arm flexors; (5) the anterior trunk extensors; (6) the foot extensors. The short battery proved to be the more useful, but slightly less accurate.

Mac Curdy Strength Test: Mac Curdy constructed a strength test based on the formula: \[ \text{POWER} = \text{FORCE} \times \text{VELOCITY}. \] The force is measured by the strength of the legs, back and arms. The velocity is measured by the vertical jump. The Physical Capacity Index by the total force (sum of the strength tests) X vertical jump divided by 100.

The reliability of the test is high (.93). The validity is determined by correlating the Physical Capacity Score with athletic achievement. This correlation is also .93. The test may be administered to high school boys; however norms are not available for simple computation of results.

Mc Cloy's Strength Test: Mc Cloy devised a method of scoring chinning and dipping which simplified the computation of actual strength from the number of chins and body weight. Weights were added to the subject until chinning became an impossibility. Total strength then was equal to the individual weight plus the maximum weight that would allow only one dip.

Rower's Strength Index (S.I.) and Physical Fitness Index (P.F.I.):}

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15 ibid., pp. 20-26
This test consists of weight and seven tests: (1) lung capacity; (2) back strength; (3) leg strength; (4 and 5) right and left grips; and (6 and 7) pull ups and push ups. The scores made by the subject in each test are summed up as the Strength Index (S.I.) and the Physical Fitness Index (P.F.I.) quotient may then be obtained by dividing the achieved S.I. by the normal S.I. for the age and weight. The Strength Index (S.I.) indicates the strength of the large voluntary muscles of the body. It is used as a measure of general athletic ability and to classify individuals into homogeneous groups for team competition. The purpose of the Physical Fitness Index (P.F.I.) is to schedule individuals into physical education classes in accordance with their fitness for activity. It is also used to measure fitness (muscular) changes resulting from activity.

A critical statistical analysis of this test by Mc Cloy,16 Cureton, and Larson demonstrates that the arm strength formula accounts for about 90 per cent of the test as a measure of athletic ability. This arm strength is dynamic strength, which is a more significant index of motor ability than static strength. Mc Cloy17 summarizes as follows:

In case the arms are well developed as to strength, the back and legs are usually also well developed. The individual develops his legs doing activities which use the other muscles. The reverse however, is not necessarily true; for individuals who engage in running or jumping programs do not necessarily develop the arms. The correlation between chinning strength alone and all the rest of the body in a study in which this comparison was made was 91.

This analysis in no way prevents the use of the test, since these


17Ibid.
studies have implications only for a reduction in the number of test items in the total battery.

**CARDIOVASCULAR TESTING**

Experiments with physiological tests, especially of cardiovascular-respiratory nature, have been conducted in this country since 1884, when Angelo Mosso, an Italian physiologist, invented the ergograph. Mosso's original premise was that the ability of a muscle to perform was dependent upon the efficiency of the circulatory system, that is the efficiency with which fuel is supplied to the muscles and waste materials are carried away. Since then, many other scientists have worked in this field, claiming that tests based upon the cardiovascular function measured quantities variously described as functional health, physiological efficiency, organic condition, athletic condition, physical fitness, and endurance.

Actually the cardiovascular mechanism and its relation to the physical condition of the body are still not thoroughly understood. Stine indicates clearly that the regulation of the heart rate is a function of the nervous system, that the heart rate is a function of the nervous system, that the heart rate has an inverse relation to the blood pressure (Narcy's law), that the essential factor governing the output of the heart is inflow (Starling's law), and that the rate of the heart responds to venous pressure. In considering the factors that maintain normal blood pressure, Reidman

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gives the following: force of heart beat, resistance in vessels, blood volume in vessels, viscosity of the blood, and elasticity of the vessel walls.

Mc Cloy lists, in general, the following factors which may be considered as accompanying good and poor condition:

**Good Condition:**

1. Slow pulse.
2. Little rise in rate of pulse upon rising from reclining position.
3. Normal systolic pressure.
4. Rise of systolic pressure upon rising from reclining position.
5. Fairly high diastolic pressure.
6. Relatively high venous pressure.
7. Relatively small increase in pulse rate after exercise.
8. Rapid recovery of pulse rate after ceasing exercise.

**Poor Condition:**

1. Fast pulse.
2. Relatively great change in rate of pulse upon arising from reclining position.
3. Relatively low systolic pressure.
4. Drop in systolic pressure upon arising from reclining position.
5. Fairly low diastolic pressure.
6. Fairly low pulse pressure
7. Low venous pressure.
8. Great increase in pulse rate after exercise.
9. Slow recovery of pulse rate after ceasing exercise.

Upon these general statements most authors have built their cardiovascular tests. Tests in which the pulse rate is used seem to be the easiest and simplest method of checking cardiovascular fitness. Pulse rate does not represent a complete test of cardiovascular fitness but the pulse is the easiest to measure and is the most reliable of physiological variables which reflect the internal bodily efficiency in response to exercise.

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21 Charles H. Mc Cloy, *Tests and Measurements in Health and Physical Education*, p. 239.
Mc Cloy 22 concludes as follows from his study of cardiovascular variables:

The variables which can be readily measured in cardiovascular testing include pulse rates at rest, after exercise, and after rest following exercise; systolic blood pressures, and venous pressures. These may be taken reclining, sitting, or standing, and the changes of position may be recorded as well as the direct readings themselves. It is probable that each of these variables is modified by a number of physiological mechanisms and some of these are as yet not thoroughly understood.

The following studies indicate the effect of training on the pulse. Mitchell 23 found the pulse average 69 for the first year of training, 64.5 for the second, 56.8 for the third. Cotton 24 reports that unusually low pulse rates have been found among athletes. The averages of Olympic runners are: sprinters, 66, middle distance runners, 63, long distance runners, 61, and marathon runners, 59. Cotton 25 measured eight champion swimmers who were assembled for a national meet at Sydney, Australia. Five of these were Olympic men. The mean basal pulses, measured in a hotel the evening before the meet, were 52, 50, 42, 40, 53, 47, 49, 47, with a mean of 47.5. This report shows that normal young men, who have almost no athletic history, average 66; those with average athletic history average 63; those with relatively greater athletic history average 57. Superior athletes average 50, and Olympic swimmers with ten years training average 47.


25Ibid.
White\textsuperscript{26} collected a number of electrocardiograms of athletes with extremely low pulses. Mac Mitchell had a basal pulse of 37 and it had been as low as 31. Glen Cunningham had a pulse rate of 38 to 40; Hurni's was 42. These low pulses have been the concern of medical examiners but no definite evidence has been presented as yet that such occurrence in apparently healthy athletes is harmful to health in the long run.

The review of literature of the cardiovascular system and cardiovascular testing could hardly be inclusive. A sampling of literature in a few areas is the procedure followed in this study. The following illustrative studies have been selected for their relation to this problem. They are those which may contribute to a clearer explanation of some portion of this report.

Berg\textsuperscript{27} summarizes his studies on individual differences in respiratory gas exchange during recovery from moderate exercise as follows:

1. In any age group the more physically fit individuals tend to have lower recovery constants, and in addition rigorous training of one subject brought about a 16 per cent reduction in the CO\textsubscript{2} and O\textsubscript{2} recovery constants.

2. The possibility is considered that the limiting factors in the rate of O\textsubscript{2} consumption and CO\textsubscript{2} elimination during recovery are circulatory in nature.

Faltby and Wiggers\textsuperscript{28} investigated the question whether constriction

\begin{footnotesize}
\begin{itemize}
\item \textsuperscript{26}P. D. White, "Bradycardia (below 40) in Athletes, Especially in Long Distance Runners," \textit{Journal of the American Medical Association}, 120:642, 1942.
\item \textsuperscript{27}W. E. Berg, "Individual Differences in Respiratory Metabolism during Recovery from Moderate Exercise," \textit{American Journal of Physiology}, 149:597-610, June, 1947.
\end{itemize}
\end{footnotesize}
of arteries during estimation of blood pressures elevates the pressures in the proximal end to such an extent that pressure readings do not correspond to those in the aorta. The results showed that the true systolic pressure in the proximal end is elevated very little and sometimes not at all.

Elbel and Green\textsuperscript{29} conducted a study in regard to the height of the stool used in numerous cardiovascular tests. They found that the height of the bench and the duration of the step-up exercise do not significantly alter the pulse rate if the pulse record is taken one minute after the exercise. After 30 seconds of exercise the average increment is 3.7 beats per minute greater for each two inch increase in the height of the bench. After 60 seconds of exercise, the increment becomes 5.6 beats per minute greater for each two inch increase.

Metheny, Brouha, Johnson, and Forbes\textsuperscript{30} did a very interesting study concerning the male vs. the female in proportional physical fitness. The conclusions indicated, as a group, women are less fit than men for moderate and strenuous exertion. The "best" woman equalled in every respect the performance of the "poorest" man in the strenuous exhausting exercise. They showed slightly greater fatigue as a result of fifteen minutes of non-exhausting exercise in which a steady state was reached and maintained. The differences between the averages of the men and women are similar in nature to those between the trained and untrained.


From his study on the effect of weight loss by dehydration and withholding of food from wrestlers, Tuttle\textsuperscript{31} summarizes as follows:

A comparison of the data collected after weight loss with those before justifies the conclusion that the weight loss experienced within the limits of this study, has no detrimental effect on the physiologic responses investigated except that there is a slight increase in the heart rate, and a slight decrease in vital capacity.

This study indicated that a wrestler may safely lose up to five percent of his body weight without suffering any detrimental effects.

\textbf{Tuttle Pulse Ratio Test:\textsuperscript{32}} The test represents the ratio of the resting pulse rate to the pulse rate after exercise. The conduct of the test consists of an exercise of stool stepping at a height of 13 inches for one minute. Tuttle's ratio is found by dividing the total pulse for two minutes, after a given amount of exercise, by the resting pulse rate for one minute. This standard ratio is 2.5. The number of steps required to yield a 2.5 ratio is converted to per cent efficiency. The individual with the largest number of steps required to yield a 2.5 ratio is the most efficient. The formula to determine the efficiency is:

\[ \text{per cent efficiency} = \frac{100 \times \text{(Number of steps for a 2.5 ratio)}}{50} \]


\textsuperscript{32}W. W. Tuttle, "The Use of the Pulse Ratio Test for Rating Physical Efficiency," \textit{Research Quarterly}, 11:5-17, May, 1931.
Stone's Cardiovascular Test: This test is computed by the formula:

\[
\frac{\text{Pulse pressure (sitting)}}{\text{Diastolic pressure (sitting)}}
\]

The logic of this test is based upon the assumption that the pulse pressure should average half of the diastolic pressure and a third of the systolic blood pressure.

Carlson Fatigue Test: The Carlson Fatigue Test uses pulse rate after exercise. The exercise consists of spot running. The subjects count each right foot contact to the ground. The subject runs in place as fast as possible in ten second innings for ten innings with ten seconds rest between consecutive innings. Five pulse rates are taken: (1) before exercise; (2) after exercise; (3) two minutes after exercise; (4) four minutes after exercise; (5) six minutes after exercise. The quick return of pulse rate to normal after exercise and the increase of foot contacts in the running in place is an index of good condition.

Schneider Cardiovascular Test: The Schneider Test resulted from work during World War I with aviators. Pulse rate and blood pressure in the horizontal and standing positions were used, plus the recovery ability of the pulse rate after exercise. The scoring scheme is arbitrarily established on the assumption that fatigue and efficiency are shown in

33W. J. Stone, "The Clinical Significance of High and Low Pulse Pressures with Special Reference to Cardiac Load and Over-Load," Journal of the American Medical Association, 14:1256-9, October 14, 1913.


comparing the reclining heart rate with the increase on standing: standing pulse rate with pulse after exercise; return of pulse rate to normal; and systolic pressure standing compared with reclining. The exercise for this test consists of stepping on an eighteen inch stool five times in fifteen seconds. Schneider has a table for scoring each of the six phases of his test. Each part of the test can be rated from a plus 3 to a minus 3. The highest possible score is plus 18 and the lowest minus 18.

Barach's Energy Index: This test purports to measure the energy expended by the heart. It is computed by the formula:

\[
\text{Pulse rate (systolic pressure plus diastolic)} \times \frac{100}{
\]

The normal range of the index is 70 to 220 with a mean of 140.85. A high index means increased cardiovascular energy, and a low index means inability to deliver a normal amount of blood.

Harvard Step-Test: This test was developed in the Harvard Fatigue Laboratory in answer to a World War II need for a simple circulatory test of physical fitness. It was based upon general cardiovascular testing principles that had already been accepted. One of the early experiments with this test showed the following results. Excellent performers on a treadmill had a distinctly lower starting pulse, but the pulse rates failed

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to differentiate the subjects of ordinary ability; a good relation was found for all subjects in acceleration of the pulse rate after running five minutes. The fit men had lower pulses in general.

<table>
<thead>
<tr>
<th>Ordinary Rate</th>
<th>After Run</th>
</tr>
</thead>
<tbody>
<tr>
<td>129 Ordinary men</td>
<td>156</td>
</tr>
<tr>
<td>18 Fit oarsmen</td>
<td>130</td>
</tr>
</tbody>
</table>

Some pulses went as high as 210 or more. Maximum rates ranged from 167 to 213 averaging 193 for 265 subjects. These experiments led to the standardization of the Harvard 5-minute Step-Test on a 20 inch bench in 1942. The most acceptable pulse rate was recuperation pulse count from the maximum pulse rate immediately after the standard exercise.

There is no doubt that men improve steadily with training. There is much evidence that pulse rates and step test scores diminish in size with exercise programs. For instance, Middleton found that a group of football players gave lower pulse rates at the end of a season than at the start. Voorhees found a correlation of 0.55 between resting pulse rate and improvement in the endurance of track men, and 0.79 between acceleration of pulse rate during exercise and the same endurance gain. Peppers study shows that track running reduces the pulse rates somewhat more than body building, but the differences between the effect of these activities is not great, whereas, it is clear that any strenuous exercise will reduce the resting pulse rates before and after exercise.


41 L. Voorhees, Thesis, University of California, 1939.

CHAPTER III

PROCEDURE

The subjects used in this study included two groups. The first consisted of ten boys who reported for wrestling the first part of December immediately following the beginning of the winter quarter. To determine the cardiovascular development of this group the Harvard Step Test was administered ten times at five distinct intervals during the season. The Harvard step test consists of an individual stepping up and down on a stool 20 inches high for five minutes at the rate of 30 times a minute. After the exercise the subject sits down for one minute of recovery then counts his pulse rate for 30 seconds. Following the first counting he sits for 30 more seconds before counting his pulse again for 30 seconds. This process is repeated after 30 more seconds of rest. The formula used for determining the score is:

$$\frac{\text{Duration of Exercise in Seconds} \times 100}{2 \times \text{Sum of Pulse Counts in Recovery}}$$

The derived quotient constitutes a score of cardiovascular efficiency. A high score indicates good cardiovascular efficiency. The less the total pulse rate the higher the score.

---

The strength of the individuals was determined by the Rogers Strength Test. It consists of six items.

1. Left grip-hand dynameter
2. Right grip-hand dynameter
3. Lung capacity-spirometer
4. Leg lift-lift dynameter
5. Back lift-push ups plus pull ups \( \frac{X \text{ weight}}{10} \)

The scores which are recorded from each event are totaled to give the strength index. Rogers has developed a table of norms for the strength index based on age and weight. To indicate an individual's physical fitness the Achieved Strength Index which is a total of the six tests is divided by the norm.

\[
\text{Achieved Strength Index} \times 100 \quad \frac{\text{X}}{\text{Normal Strength Index}}
\]

The higher the quotient the greater the indication of strength.

These tests were administered at five different times. These were: (1) the start of the season, (2) just before Christmas vacation, (3) right after Christmas vacation, (4) just before mid-term examinations and (5) at end of the season. During each of the above intervals the Harvard step test was given twice and the Rogers strength test once.

A preview of the group of wrestlers revealed the possibility of a physiological difference between two segments. The wrestlers were therefore divided into Group A (those with previous conditioning) and Group B (those without previous conditioning).

As a control group a physical education class (service) was used. The same tests were used as with the experimental group. The physical

\[2\text{Ibid., p. 168}\]
education class was tested three times during the same period as the wrestlers. This period closely corresponded to the winter quarter of school. They were tested at the beginning, middle and end of the quarter. The Harvard step test was given twice and the Rogers strength test once during each of the three periods.

This group showed some individuals unrelated in ability to the remainder of the class. This fact was accounted for by other training. The outstanding individuals were participating in track in conjunction with physical education. These individuals were placed in Group C. The remainder of the physical education class was called Group D. Throughout the content of this report Group D will be considered as the control group.

DELIMITATION OF THE PROCEDURE

The small number of individuals available for this project reduced the conclusiveness of the study. All personnel available were utilized. The results were affected by variations in the testing procedures such as sickness, absences, effort, posture, persistence, and attitude of the individual. The occurrence of holidays, vacations and tests produced fluctuations in the data. In some cases these fluctuations seemed meaningful and will be explained. However, they make it more difficult to draw complete unbiased conclusions.
CHAPTER IV

RESULTS

The complete test results for each participating individual are tabulated in graphic form in the appendix. The data of all individuals in each of the four groups are presented in this chapter. The most significant findings pertain to the study of the groups. Secondary conclusions will be formulated from the observation of individual test results. A comparative procedure will be followed to isolate specific phenomena which occur in a variable pattern between the four groups. The analysis of each group will not be complete until the ultimate objective, comparison of groups, is completed. Individual study, group study, and group comparison, summarize the systematic presentation of the results.

Group A (Chart I) -- Wrestlers With Previous Football Training

This group was tested for a period of approximately two and a half months. The cardiovascular test scores showed an increase during the testing period. The score of the first test was 80 and of the final test was 91. This was an increase of eleven points. During the testing period two periods of training showed a decrease in cardiovascular condition. There was a drop of five points in the score of the test given after Christmas vacation from the one given before the vacation. This vacation was of two weeks duration in which the participants had no wrestling training.
Chart I

Strength and cardiovascular test averages of group A:

Wrestlers with previous football training.

--- Rogers strength test
--- Harvard step test

<table>
<thead>
<tr>
<th>Dec</th>
<th>Jan</th>
<th>Feb</th>
</tr>
</thead>
<tbody>
<tr>
<td>7</td>
<td>9</td>
<td>13</td>
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<tr>
<td>15</td>
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<td>6</td>
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<td>14</td>
</tr>
<tr>
<td>16</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

xmas vacation
mid-term exams
Also, a drop of five points was recorded after mid-term examinations when the participants worked out very little or not at all. Except for these two periods, progress was always upward.

The strength test scores showed an increase of nine points from the beginning to the end of the testing period. The first test score was 76 and the final score was 90. Christmas vacation and mid-term examinations did not reverse the progress of strength improvement. The strength scores never regressed.

**Group B** (Chart II) -- Wrestlers Without Previous Conditioning

Cardiovascular improvement increased 17 points from the beginning to the end of the training period. The first test produced a score of 84 and the final test a score of 101. This group showed a drop of nine points following Christmas vacation. An increase of 11 points was recorded following the mid-term examination period. The cardiovascular improvement was not constantly upward. Even though the final score showed an increase of 17 points, there were four tests which showed a decrease.

The test results of this group were not consistent and fluctuated readily. The fact that increases of improvement were of great proportion and decreases small, except over Christmas vacation, accounts for the 17 point over-all improvement.

Strength improvement showed a steep rise between the first and second tests and leveled off to a more gradual increase in succeeding tests. The strength improvement increased 17 points. The first test score was 77 and the final score was 91. Test scores showed no significant fluctuations following Christmas vacation and mid-term examinations.
Chart II

Strength and cardiovascular test averages of group B

Wrestlers without previous conditioning.

--- Rogers strength test
--- Harvard step test

120
115
110
105
100
95
90
85
80
75
70
65
60
55
50

7 8 13 15 4 6 17 18 14 16

xmas vacation mid-term exams
Group C (Chart III) — Physical Education Students with Track Training

Cardiovascular test scores ranged from 91 on the first test to 99 on the last. This was a total increase of 8 score points. The final score of 99 was not the highest cardiovascular test score which this group had attained. The two tests administered during the middle of the training period both produced scores of 105. Christmas vacation and mid-term examinations will not be considered in the results of groups C and D, because the three testing periods occurred too long afterwards to produce substantial relationships. The accuracy of the cardiovascular test scores of this group can be exhibited by the close relationship of the two test scores which were recorded one week apart for each of the three intervals in which this group was tested. The first interval scores show a difference of one point. There is no difference in the two test scores recorded during the second and last testing intervals.

Strength development of this group decreased from the start to the conclusion of the testing period by two score points. The first test score was 92 and the last score was 90. The two score points are actually of little significance in the difference of strength, but they do show that the group remained relatively stable.

Group D (Chart IV) — General Physical Education Student

The range of cardiovascular improvement as indicated by test scores was from 78 on the first test to 90 on the final. This group showed a significant increase from the first to the second testing period. The test scores showed no increase from the second to the last period. The
Chart III

Strength and cardiovascular test averages of group C.

Physical education students with track training in conjunction.

- Rogers strength test
- Harvard step test

beginning middle end

120 115 110 105 100 95 90 85 80 75 70 65 60 55 50

10 12 17 18 20 25 15 17 22

Fall  Fall
The two tests administered during the first interval of the training period showed an increase in score value in the one week period indicated. The next two testing periods showed no significant increase or decrease between the two weeks the tests were administered in the second and third testing intervals.

The strength test scores show a four point increase in improvement. The increase was continuous throughout the testing intervals of the training period.

Group Comparison (Charts I, II, III, IV)

The cardiovascular test scores for the four groups showed a range of increase from the first to the last test as follows:

- Group A = 11 points (80 to 91).
- Group B = 17 points (84 to 101).
- Group C = 8 points (91 to 99).
- Group D = 12 points (78 to 90).

All groups showed an increase. Group B had the greatest increase (17 points) and Group C had the smallest (8 points). Group D had the lowest score on the first test and Group C, that had the smallest increase, had the highest test score on the first test.

The highest and lowest cardiovascular test scores recorded by each group at any point of the testing period are as follows:

<table>
<thead>
<tr>
<th>Group</th>
<th>Highest</th>
<th>Lowest</th>
</tr>
</thead>
<tbody>
<tr>
<td>Group A</td>
<td>91</td>
<td>80</td>
</tr>
<tr>
<td>Group B</td>
<td>104</td>
<td>84</td>
</tr>
<tr>
<td>Group C</td>
<td>105</td>
<td>90</td>
</tr>
<tr>
<td>Group D</td>
<td>90</td>
<td>78</td>
</tr>
</tbody>
</table>

The strength test scores for the four groups showed a range of increase from the first to the last test as follows:
Chart IV

Strength and cardiovascular test averages of group D.

General physical education students.

--- Rogers strength test
--- Harvard step test

begining  middle  end

120  115  110  105  100  95  90  85  80  75  70  65  60  55  50

10  12  17  18  20  25  15  17  22
Dec  Jan  Feb
Group A = 9 points (76 to 85).
Group B = 14 points (77 to 91).
Group C = -2 points (92 to 90).
Group D = 4 points (76 to 80).

All groups, except C, showed a range of increase. Group B had the greatest increase (14 points). Groups A, B, and D were closely grouped with the lowest first test scores. Group C still ranked above two other groups in strength test scores after losing two points from the first to last test.

The highest and lowest strength test score compiled for each group at any point throughout the training period are as follows:

<table>
<thead>
<tr>
<th>Group</th>
<th>Highest</th>
<th>Lowest</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>95</td>
<td>76</td>
</tr>
<tr>
<td>B</td>
<td>91</td>
<td>77</td>
</tr>
<tr>
<td>C</td>
<td>92</td>
<td>90</td>
</tr>
<tr>
<td>D</td>
<td>80</td>
<td>76</td>
</tr>
</tbody>
</table>

The relation of the range of improvement of strength to cardiovascular are as follows: (score points)

<table>
<thead>
<tr>
<th>Strength</th>
<th>Cardiovascular</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>9</td>
</tr>
<tr>
<td>B</td>
<td>14</td>
</tr>
<tr>
<td>C</td>
<td>-2</td>
</tr>
<tr>
<td>D</td>
<td>4</td>
</tr>
</tbody>
</table>

CHARACTERISTICS OF INDIVIDUAL DATA

Group A Chart V a, b, c, Appendix

Subjects M.D., D.V., and E.J. showed a characteristic that was quite uncommon among the majority of subjects used in this study. Their strength test scores lay above the cardiovascular test scores on the individual graphs. Every individual in this group, except W.H., lost weight
through the wrestling training, W.H. gained two pounds. All individuals, except W. H. and N.D. had smaller cardiovascular test scores following Christmas vacation. W.H. remained the same as before vacation and N.D. gained 5 score points. W.H. had a strength score of 72 at the beginning of training and never equalled this score again until the last test of the training period. D.B., an endomorph, lost the most weight, (14 pounds). T.E., an ectomorph, was next in weight lost, (10 pounds).

Group B Chart VI a, b, Appendix

L. K. was the only individual in this group whose strength exceeded his cardiovascular development, as expressed in score units. None of the subjects in this group was affected by a drop in cardiovascular test scores by mid-term tests. Two of the individual scores gained at this point and two stayed constant. D.G. was the only subject not to lose in cardiovascular development over Christmas vacation. His score remained constant. Every participant lost some weight, ranging from three to nine pounds. Subjects P.M. and J.S. reached their highest cardiovascular score attainment before the end of the season and lost score points by the time of the final test. L.K. was the only subject to accomplish the same task in regard to his strength scores.

Group C Chart VII a, b, Appendix

Three of the four individuals in this group gained weight. Two of the four subjects decreased in strength test score points from the first to the last test. D.B. at one time had increased in cardiovascular test points 13 points from the beginning, but by the last two tests had gone
lower than his starting score at the beginning of the training period. All subjects attained their peak cardiovascular scores during the middle testing period and had dropped down some extent by the last testing interval. W.L. had strength scores which exceeded his cardiovascular scores.

Group D Chart VIII a, b, c, Appendix

Only two of the twelve individuals in this group lost weight. B.P. was the only subject whose strength exceeded his cardiovascular development in score points. D.K. and L.P. were the only participants who lost score points from the beginning to the end of the strength testing. All other subjects increased from 0 to U points. F.B. lost score points in cardiovascular testing, (5 points). Every other subject increased his cardiovascular development from 4 to 23 points.

FLUCTUATING FACTOR ANALYSIS

Group A regressed in cardiovascular test score points following both Christmas vacation and mid-term examinations. Group B did the same in regard to Christmas vacation but gained in score points following mid-term examinations. Strength test values were not altered either be break in training. Group C showed a drop in both cardiovascular and strength improvement during the last testing period. This was probably due to a decrease in their outdoor training caused by a long period of inclement weather which is not indicated on the charts.
Cardiovascular and strength condition are important phases of total body condition. The significance of these two functions are often not realized. Even the physical educator and athletic coach often underrate the value of good cardiovascular and muscular functioning when working toward gross body condition. Most physical activities in use today develop one or two of the many body functions to a great degree and disregard or merely touch upon the others. Results of this study indicate strongly that wrestling is an activity which includes both strength and cardiovascular development as well as improvements of other bodily functions.

On the basis of the data presented the following conclusions are drawn:

1. Wrestlers through regular training experience a parallel improvement in both cardiovascular and muscular condition. This is true of both groups A and B in this study.

2. Wrestlers with no previous conditioning experience the greatest strength and cardiovascular improvement of any of the groups studied. This is true even though, with the exception of group C, their beginning score is higher.

3. Wrestling training tends to reduce body weight.

4. The football players who took up wrestling did not increase in cardiovascular condition and muscular condition in proportion to wrestlers
with no previous training.

5. Indications are that cardiovascular condition is affected quickly by either a sudden increase or decrease in activity. Muscular condition is not affected as quickly.

6. Track training improves the condition of the cardiovascular system, but only holds the muscular condition at the same level.

7. Physical education activities will only increase the cardiovascular and muscular systems to a certain limit.

8. WRESTLING CONDITIONS BOTH THE CARDIOVASCULAR AND MUSCULAR SYSTEMS AT THE SAME TIME.

On the basis of the above summary and conclusions drawn from this study, the following recommendations are made:

1. Wrestling activities should be a part of every physical education program because they include exercises of the upper body, which are extremely important in the development of muscular condition. Mc Cloy\(^1\) states that arm strength contributes about 90 per cent of the total score of the Rogers Strength Index.

2. Track training should include more exercise of the upper body.

3. Football players need more conditioning of the cardiovascular system and upper body muscles.

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Measurement and Evaluation Materials in Health, Physical Education


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pany, 1927.

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of Iowa, 1936.

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**PERIODICALS**


**UNPUBLISHED MATERIALS**


APPENDIX

Graphic presentations of the raw data collected for this study are shown in Appendix Charts V-VIII inclusive.
Charts V-a

Individual graphic results of cardiovascular (Harvard) and strength (Rogers) testing throughout wrestling season.

Wrestlers-Group A (6)
with previous conditioning (PB).

<table>
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<th>Mid-term</th>
<th>Vacation</th>
<th>Exams</th>
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<td>75</td>
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<td>70</td>
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<td>65</td>
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<tr>
<td>60</td>
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<tr>
<td>55</td>
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<tr>
<td>50</td>
<td></td>
<td></td>
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</tr>
</tbody>
</table>

---

Rogers strength test
Harvard step test

Subject: DR
Age: 18
Height: 5'11
Weight: beginning 186 end 182
Somatotype: Endomorphic
Previous Training: Football
Persistence: Good

Subject: ND
Age: 19
Height: 6'
Weight: beginning 187 end 180
Somatotype: Mesomorphic
Previous training: Football
Persistence: Excellent
Charts V-b

Wrestlers-Group A (continued)

--- Rogers strength test
--- Harvard step test

<table>
<thead>
<tr>
<th>Dec</th>
<th>Jan</th>
<th>Feb</th>
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</thead>
<tbody>
<tr>
<td>79</td>
<td>131546</td>
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</tr>
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<tr>
<td>xmas</td>
<td>mid-term</td>
<td></td>
</tr>
<tr>
<td>vacation</td>
<td>exams</td>
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</tr>
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</table>

<table>
<thead>
<tr>
<th>Dec</th>
<th>Jan</th>
<th>Feb</th>
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</thead>
<tbody>
<tr>
<td>79</td>
<td>131546</td>
<td>1791416</td>
</tr>
<tr>
<td>120</td>
<td>120</td>
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</tr>
<tr>
<td>xmas</td>
<td>mid-term</td>
<td></td>
</tr>
<tr>
<td>vacation</td>
<td>exams</td>
<td></td>
</tr>
</tbody>
</table>

Subject: TM
Age: 18
Height: 5'10
Weight: beginning 153 end 144
Somatotype: Ectomorphic
Previous training: Football
Persistence: Excellent

Subject: BJ
Age: 19
Height: 5'7
Weight: beginning 163 end 168
Somatotype: Mesomorphic
Previous training: Football
Persistence: Excellent
Charts V-c

Wrestlers-Group A (continued)

---- Rogers strength test

Harvard step test

<table>
<thead>
<tr>
<th>Subject: WH</th>
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</thead>
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<td>Age: 18</td>
</tr>
<tr>
<td>Height: 6'2</td>
</tr>
<tr>
<td>Weight: beginning 182 end 201</td>
</tr>
<tr>
<td>Somatotype: Mesomorphic</td>
</tr>
<tr>
<td>Previous training: Football</td>
</tr>
<tr>
<td>Persistence: Good</td>
</tr>
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</table>

<table>
<thead>
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<th>Subject: IV</th>
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</thead>
<tbody>
<tr>
<td>Age: 18</td>
</tr>
<tr>
<td>Height: 5'10</td>
</tr>
<tr>
<td>Weight: beginning 200 end 203</td>
</tr>
<tr>
<td>Somatotype: Endomorphic</td>
</tr>
<tr>
<td>Previous training: Football</td>
</tr>
<tr>
<td>Persistence: Excellent</td>
</tr>
</tbody>
</table>
Charts VI-a

Individual graphic results of cardiovascular (Harvard) and strength (Rogers) testing throughout wrestling season.

Wrestlers-Group B
without previous conditioning. (4)

--- Rogers strength test
--- Harvard step test

<table>
<thead>
<tr>
<th>Subject: DG</th>
<th>Subject: LK</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age: 18</td>
<td>Age: 18</td>
</tr>
<tr>
<td>Height: 5'10</td>
<td>Height: 5'11</td>
</tr>
<tr>
<td>Weight: beginning 157 and 154</td>
<td>Weight: beginning 165 and 160</td>
</tr>
<tr>
<td>Somatotype: Ectomorphic</td>
<td>Somatotype: Mesomorphic</td>
</tr>
<tr>
<td>Previous training: None</td>
<td>Previous training: None</td>
</tr>
<tr>
<td>Persistence: Excellent</td>
<td>Persistence: Excellent</td>
</tr>
</tbody>
</table>
Charts VI-b

Wrestlers Group B (continued)

--- Rogars strength test
--- Harvard step test

| Subject: PM | Subject: JS |
| Age: 19 | Age: 18 |
| Height: 5'11" | Height: 5'9" |
| Weight: beginning 171 and 168 | Weight: beginning 165 and 155 |
| Somatotype: Mesomorphic | Somatotype: Mesomorphic |
| Previous conditioning: None | Previous conditioning: None |
| Persistence: Excellent | Persistence: Excellent |
Individual graphic results of cardiovascular (Harvard) and strength (Rogers) testing at the beginning, middle, and end of the winter quarter.

General physical education students—Group C with track training in conjunction (4)

--- Rogers strength test  --- Harvard step test

Beginning  Middle  End  Beginning  Middle  End

<table>
<thead>
<tr>
<th>10</th>
<th>12</th>
<th>17</th>
<th>18</th>
<th>20</th>
<th>25</th>
<th>15</th>
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<tbody>
<tr>
<td>Dec</td>
<td>Jan</td>
<td>Feb</td>
<td>Dec</td>
<td>Jan</td>
<td>Feb</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Subject: DB
Age: 19
Height: 5'11"
Weight: beginning 156 and 162
Somatotype: Mesomorphic
Previous conditioning: X-country
Persistence: Excellent

Subject: CC
Age: 18
Height: 5'11"
Weight: beginning 148 and 151
Somatotype: Mesomorphic
Previous conditioning: None
Persistence: Poor
Charts VII-b

General physical education—Group C (continued)

--- Rogers strength test

--- Harvard step test

<table>
<thead>
<tr>
<th>Subject: WL</th>
<th>Subject: HP</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age: 18</td>
<td>Age: 18</td>
</tr>
<tr>
<td>Height: 5'9</td>
<td>Height: 5'10</td>
</tr>
<tr>
<td>Weight: beginning 212 and 211</td>
<td>Weight: beginning 140 and 144</td>
</tr>
<tr>
<td>Somatotype: Mesomorph</td>
<td>Somatotype: Endomorph</td>
</tr>
<tr>
<td>Previous conditioning: None</td>
<td>Previous conditioning: None</td>
</tr>
<tr>
<td>Persistence: Poor</td>
<td>Persistence: Excellent</td>
</tr>
</tbody>
</table>
Charts VIII-a

Individual graphic results of cardiovascular (Harvard) and strength (Rogers) testing at the beginning, middle and end of the quarter.

General physical education students - Group D

<table>
<thead>
<tr>
<th>Subject: DB</th>
<th>Subject: BB</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age: 18</td>
<td>Age: 18</td>
</tr>
<tr>
<td>Height: 5'6</td>
<td>Height: 5'8</td>
</tr>
<tr>
<td>Weight: beginning 155 end 157</td>
<td>Weight: beginning 144 end 149</td>
</tr>
<tr>
<td>Somatotype: Mesomorphic</td>
<td>Somatotype: Endomorphic</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Subject: FB</th>
<th>Subject: CB</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age: 18</td>
<td>Age: 18</td>
</tr>
<tr>
<td>Height: 5'7</td>
<td>Height: 5'11</td>
</tr>
<tr>
<td>Weight: beginning 145 end 150</td>
<td>Weight: beginning 140 end 152</td>
</tr>
<tr>
<td>Somatotype: Mesomorphic</td>
<td>Somatotype: Ectomorphic</td>
</tr>
</tbody>
</table>
Charts VIII-b

General physical education Group D (continued)

--- Rogers strength test
--- Harvard step test

<table>
<thead>
<tr>
<th></th>
<th>10</th>
<th>12</th>
<th>17</th>
<th>18</th>
<th>20</th>
<th>25</th>
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<tbody>
<tr>
<td>Dec</td>
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<td>95</td>
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<td>70</td>
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</tr>
<tr>
<td>Feb</td>
<td>100</td>
<td>95</td>
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<td>85</td>
<td>80</td>
<td>75</td>
<td>70</td>
<td>65</td>
<td>60</td>
</tr>
</tbody>
</table>

Subject: TF
Age: 18
Height: 5'10
Weight: beginning 130 end 133
Somatotype: Ectomorphic

---

Subject: DK
Age: 18
Height: 5'7
Weight: beginning 147 end 143
Somatotype: Endomorphic

---

Subject: RL
Age: 17
Height: 6'
Weight: beginning 156 end 156
Somatotype: Mesomorphic

---

Subject: LL
Age: 18
Height: 6'2
Weight: beginning 165 end 162
Somatotype: Ectomorphic
### Charts VIII-c

#### General physical education—Group D (continued)

<table>
<thead>
<tr>
<th>Subject</th>
<th>Age</th>
<th>Height</th>
<th>Weight: beginning</th>
<th>Weight: end</th>
</tr>
</thead>
<tbody>
<tr>
<td>B0</td>
<td>18</td>
<td>5'9</td>
<td>138</td>
<td>142</td>
</tr>
<tr>
<td>LP</td>
<td>18</td>
<td>5'10</td>
<td>161</td>
<td>165</td>
</tr>
<tr>
<td>FS</td>
<td>17</td>
<td>5'9</td>
<td>137</td>
<td>142</td>
</tr>
<tr>
<td>FW</td>
<td>19</td>
<td>5'1</td>
<td>155</td>
<td>160</td>
</tr>
</tbody>
</table>

**Notes:**
- Rogers strength test
- Harvard step test

---

**Graphs:**
- The graphs show the changes in scores for strength tests over time for subjects B0, LP, FS, and FW.
- The x-axis represents the months (Dec, Jan, Feb) while the y-axis represents the scores.

---

**Detailed Analysis:**
- **Subject B0:**
  - Age: 18
  - Height: 5'9
  - Weight: Beginning: 138 lbs, End: 142 lbs
- **Subject LP:**
  - Age: 18
  - Height: 5'10
  - Weight: Beginning: 161 lbs, End: 165 lbs
- **Subject FS:**
  - Age: 17
  - Height: 5'9
  - Weight: Beginning: 137 lbs, End: 142 lbs
- **Subject FW:**
  - Age: 19
  - Height: 5'1
  - Weight: Beginning: 155 lbs, End: 160 lbs