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A study of the relation of endurance to success in athletics.

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BOSTON UNIVERSITY
SCHOOL OF EDUCATION

Thesis

A STUDY OF
THE RELATION OF ENDURANCE TO
SUCCESS IN ATHLETICS

Submitted by

Eleanor Duke Copley
(B. S. Ed., Boston University, 1939)

In partial fulfillment of the requirements for
the degree of Master of Education

1954
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Second Reader: James A. Wylie, Ed. M., Ed. D., Professor of Education
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CHAPTER I
INTRODUCTION

Statement of the Problem

The purpose of this study was to determine whether a record of endurance as measured by the ergograph and recorded on the kymograph could be used as a method of foretelling probable success in athletics among girls at the senior high school level.

Analysis of the Problem

The subordinate problems involved in this study were:

1. To classify the pupils to be tested in two groups, athletes and non-athletes, on the basis of records of participation in interscholastic competition.
2. To test both groups for endurance.
3. To find the T scores for each group.
4. To determine the correlation of the T scores and the participation record.
5. To summarize the findings and evaluate the test.
6. To make recommendations for further study.

Delimitation of the Problem

Recognizing that emotional, mental and physical factors might not be the cause of non-participation, every effort was
made to eliminate from the group those girls who had the following reasons for not participating:

1. Financial need requiring after-school employment
2. Family or home responsibilities which prevented their participating in any extra school activities

Justification of the Problem

Some people dismiss the non-participation of girls in sports by saying, "She isn't the athletic type."

Is there an athletic type?

Rathbone,¹ in her book entitled Relaxation, makes the following statement concerning inherent constitution:

"The anthropologist and students of physique distinguish between two marked types, one called asthenic (weak muscled, and with long, spindle-like limbs), and one called hypersthenic (excessively strong, and with chubby, rounded features and limbs). An interpretation of the information accumulated by these scientists, in their study of organic strength and personality through anatomical signs, is that the asthenic type lacks vitality and so becomes easily fatigued and seriously depressed under strain."

Is it the asthenic type which people in general refer to as the non-athletic type?

Physical educators use various methods of classifying students for participation in class activities, but rarely are the same methods used for picking members of varsity teams. Choice of team members usually is based on performance during practices.

and try-outs, coupled with the coach's knowledge of the individual's ability to compete. Every coach has methods of determining which players have the skills necessary for successful participation in a given sport, but whether they have the mental and emotional stability needed for successful competition is hard to determine. Endurance, the ability to prolong physical activity beyond the point of fatigue, is essential to successful competition and is an unrecognized quality until noted during the competition.

Any test which is designed to take some of the guesswork out of picking members of a team deserves consideration.

Related Studies

Research is being conducted in all areas of physical education and tests of skill, achievement, motor ability and physical fitness are plentiful for both boys and girls. Many of these tests list endurance as one of the factors for which the test is devised, but very often the two factors of speed and endurance are considered jointly. The linking of these two factors indicates that a person taking the test will be expected to move about and that agility and coordination are also being tested. An example of this type of test is the "stairs test" conducted by Collins and Howe.¹ The stated objective of the

¹ Vivian D. Collins and Eugene C. Howe, "A Preliminary Selection of Tests of Fitness," American Physical Education Review XXIX (December, 1924)
test was to estimate, from the shape of a recorded curve, a subject's endurance, the algebraic sum of her cardiac efficiency, her neuromuscular skill and economy, and her courage. The testing procedure consisted of having the subject run, at top speed, up and down a flight of twelve steps, touching a key at the top of the flight and touching a spot on the wall a step from and opposite the bottom of the flight. Records of the time of each round trip were registered on a rapidly moving long-paper kymograph by means of signal magnets.

A second combination of factors for which tests are devised is that of strength and endurance. This combination is often found in tests of motor ability and physical fitness. A well-known example of this type is the Physical Capacity Tests devised by Rogers.¹ The testing procedure which requires special apparatus is designed to test lung capacity, strength of hands, arms, legs, and back. The subject is encouraged to exert his maximum effort to obtain the best possible score. Endurance enters the testing as a result of this extra effort.

Research disclosed no test devised specifically for the purpose of determining the relation of endurance to success in athletics. The importance of endurance is recognized, but most of the existing tests were designed to measure endurance in a specific area of athletics, i.e., Cureton's test in swimming.²

¹ Frederick R. Rogers, Physical Capacity Tests, A.S.Barnes Company, New York, N.Y.

Studies by Anderson,\textsuperscript{1} Carpenter,\textsuperscript{2} and Rogers\textsuperscript{3} have dealt with the importance of strength and endurance in predicting athletic ability. Although all three of these studies were concerned with girls, Rogers' study was based on his Physical Capacity Tests and there is some doubt concerning the validity of the Physical Fitness Indices (P.F.I.) for girls.

Three tests which required special apparatus and no moving about on the part of the subject being tested are described in the book entitled \textit{Tests and Measurements in Physical Education} by Bovard, Cozens and Hagman,\textsuperscript{4} under the heading "Tests of Capacity and Endurance."

The first of the three tests, which appears under the subheading "Ergographic Experiments," is of particular importance to this study since the apparatus involved is similar to that used in conducting this experiment. According to this report the ergograph, developed in 1884 by Mosso, has been modified repeatedly to conform to whatever problem was under investigation, but without changing the principle involved. The ergo-

\textsuperscript{1} Theresa W. Anderson, \textit{The Research Quarterly}, American Association for Health, Physical Education and Recreation, Washington, D.C., (March 1936), 7:136

\textsuperscript{2} Aileen Carpenter, \textit{The Research Quarterly}, American Association for Health, Physical Education and Recreation, Washington, D.C., (December 1938), 9:22

\textsuperscript{3} Frederick R. Rogers, \textit{Fundamental Measures in Physical Education}, Pleiades Company

graph consists of a support for the reception of the forearm and a weight suspended from a pulley wheel which is connected by means of a thread with the index or middle finger of the subject, and is equipped with a lever adjusted to record lines on the smoked paper of a kymograph. The character of the successive muscular contractions obtained by flexing and relaxing the finger was employed as an index of estimating the muscular power and general condition of the person being tested.

The second test, referred to by the authors as "Kellogg's Dynamometer," is of no particular importance to this study, since it was a test devised to measure the strength of various muscle groups by means of a dynamometer.

The third in this group is referred to as the "U Tube Manometer or 40 mm. Mercury Test." It involved blowing into a tube, holding the breath and recording the pulse. The length of time that the breath was held and the type of pulse recorded were used as measures of the fitness of the subject for flying duties in the Royal Air Force. It is popularly known as the "endurance" or "fatigue test."

A review of research and literature in the area of endurance testing indicates that very little has been done on the secondary level with girls, which is the primary objective of this study.
CHAPTER II
METHOD OF PROCEDURE

The purpose of this study was to determine whether endurance as measured by the ergograph could be used as a means of foretelling probable success in athletics among girls in a senior high school.

Before testing could be done the following preliminary steps were taken:

1. A review of research and literature was made in the field of endurance and testing for the purpose of (a) reviewing similar studies, (b) determining techniques of endurance testing, (c) studying types of questionnaire construction, (d) establishing T scores and correlations, and (e) analyzing results.

2. Members of the girls' physical education classes of the Gamaliel Bradford Senior High School, Wellesley Hills, Massachusetts, were informed about the proposed study. Their voluntary cooperation in submitting to the test was requested.

3. A questionnaire was given to each girl. The purpose of the questionnaire was to discover the pupil's record of participation or non-participation in interscholastic competition.

4. Answers on the questionnaire were compared with official team records kept by each coach and used in determining eligibility for athletic awards. The standards for awards were estab-
lished by the student council under the guidance of the faculty advisor and the director of health and physical education.

5. A private conference was held with those girls whose official records did not agree with their personal record of participation on the questionnaire. The coaches' records were the accepted criteria for deciding all questions, since temporary membership on a team is not accepted for points.

6. Each girl was classified as an athlete or non-athlete on the basis of having played on a varsity, junior varsity, or class team in competition with other schools.

7. Questionnaires of the non-athletes were studied to determine the reasons for non-participation. Those girls who stated that they had to work after school or had to help at home regularly were eliminated from the group to be included in the study. A statement that she was too busy in other school activities did not exclude her from the group.

After the preliminary steps were completed, the testing procedure was as follows:

1. Every girl who volunteered was tested, and every effort was made to test a girl only when she felt perfectly well.

2. Testing was conducted during a student's free time, during a study period or after school.

3. The apparatus used was an ergograph. It consisted of an arm rest, a weighted wire suspended over a wheel pulley and connected with a lever and stylus, a long paper kymograph and a metronome. Three one-kilogram weights were used.
4. The manner of testing was as follows:

a. The student placed her forearm in the arm rest in such a position that the second joint finger knuckles were just at the edge of the rest. The arm was strapped down securely.

b. The finger loop (at the end of the weighted wire) was placed over the end (nail) joint of the middle finger.

c. The kymograph was set to cause the drum to rotate at a moderate speed and the metronome was set at 76.

d. The girl was told to pull on the wire loop by flexing and extending her finger in time with the metronome. She was encouraged to continue until she felt tired. Each flexion and extension of the finger was recorded on the graph paper as the stylus was pulled back and forth across the rotating drum.

When the testing was completed the following methods were used to record the results:

1. Each student was given a number before being tested and her name and number was recorded. After the test was taken her number was recorded beside her kymograph record.

2. The number of marks on the kymograph paper were counted and transferred to the student's record.

3. The accumulated kymograph records provided the raw scores and were arranged in order from highest to lowest for the entire group.

4. Using the method devised by McCloy\textsuperscript{1} three groups of T scores were derived, one for seniors, one for sophomores, and

5. The T scores for athletes and non-athletes were arranged in order for each of the three groups, and means were found.

6. Coefficients of correlation were determined for each of the three groups by means of the biserial formula. \(^1\)

7. The data from the results of the study were analyzed, compiled into a table, and interpreted.

8. The summary, conclusions, and recommendations were formulated, based upon the data obtained.

CHAPTER III
ANALYSIS OF THE DATA

Scope of the Chapter

The material presented in this chapter is an analysis of the findings of the endurance testing and the correlation between the test results and success in athletics among tenth, eleventh and twelfth grade girls in the Gamaliel Bradford High School in Wellesley Hills, Massachusetts. The purpose of the analysis is to determine whether an endurance test of this type could be used to foretell probable success in athletics.

Using the Participation Questionnaire

Directions for Answering the Questionnaire. The questionnaire shown in Figure I was given to all members of the girls' physical education classes and a portion of the class time was allotted for answering it. The girls were urged to study the questionnaire and to check all statements that applied to them personally. It was pointed out that the items in Part I of the questionnaire were designed to verify coaches' records of their participation in after school activities, and that the items in Part II were to help the physical education director in planning future programs. The girls were assured that, since participation in extra class activities was entirely voluntary, a
FIGURE I

NAME ___________________________  CLASS ___________________________

Directions: Please check under Part I those activities in which you have participated, or under Part II the reasons why you did not participate.

Part I - I was a member of the following teams or squads:

<table>
<thead>
<tr>
<th>Team</th>
<th>10th Year</th>
<th>11th Year</th>
<th>12th Year</th>
</tr>
</thead>
<tbody>
<tr>
<td>Field Hockey Varsity</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Field Hockey Jr. Varsity</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Basketball Varsity</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Basketball Jr. Varsity</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Softball Varsity</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Softball Jr. Varsity</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Tennis Varsity</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Tennis Jr. Varsity</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cheerleaders</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Twirlers</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Tumbling</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Modern Dance</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Part II - I did not participate in after school sports because:

1. I was not interested.
2. I feel I am not good enough.
3. I tried for teams, but did not make them.
4. I work after school.
5. I am too busy with other school activities
6. I have to help at home.

FIGURE I: Questionnaire to determine the extent of participation in athletics or the reasons for non-participation.

Disinterest in such activities would in no way affect their marks or credits in the required physical education course.

Sorting the Questionnaires. After the questionnaires were answered they were divided into two groups. Those with checks
in Part I were put in the athletes' group and those with checks in Part II were placed in the non-athletes' group. They were further separated into sophomore, junior and senior classes. This sorting resulted in the following six groups: sophomore athletes, sophomore non-athletes, junior athletes, junior non-athletes, senior athletes and senior non-athletes.

All answers in Part I of the questionnaire were checked with the coaches' official records of participation.

The questionnaires were then set aside and the endurance testing was started.

Administering and Recording the Test

One hundred sixty-five girls volunteered and were tested. The number of finger pulls recorded on the kymograph, before fatigue became evident, was the score. A sharp drop in the lines made on the graph sheet indicated when the point of fatigue had been reached. As each girl finished the test, the lines made by the stylus were counted and that count was recorded as her endurance score.

When the testing was completed the questionnaires were again studied and tabulated. The tabulation disclosed that more non-athletes than athletes took the test. In the tenth-year class there were eighteen athletes and forty non-athletes tested; in the eleventh-year class, twenty-eight athletes and thirty-four non-athletes; in the twelfth-year class, twenty-one athletes and twenty-four non-athletes.
To equalize the two groups certain non-athletes were eliminated. Those students who stated that they had to work after school, or that they had to help at home, were interviewed and asked about the amount of time they devoted to the job or to the home. If they were so occupied for more than two afternoons a week they were not included in the group to be considered in the study. Eleven of the tenth-year group, five of the eleventh-year group and three of the twelfth-year group were eliminated for these reasons.

Twelve more students were excluded for other reasons. Three of the tenth-year group and one of the eleventh-year group had entered the school at mid-term of the current school year and were not eligible for participation in competitive activities. They were excluded from the study. Six of the tenth-year group were not included because their activity in a newly organized dramatic club prohibited their participation in athletic activities. One tenth-year girl was excluded because of a childhood injury and another in the same group was not included because she travels with her family for a large part of each school year.

In each instance elimination was on the basis of the girl's inability to participate through no fault of her own, rather than on the basis of her disinterest or lack of skill.

Figure II shows the reasons for elimination and the resulting equalization of athletes and non-athletes in the three class groups. The final group included thirty-six tenth-year students,
fifty-six eleventh-year students, and forty-two twelfth-year students. These one hundred thirty-four students were included in the experiment. Their questionnaires and raw scores on the endurance test served as the basis of the study.

![Figure II](image)

**FIGURE II**

<table>
<thead>
<tr>
<th></th>
<th>Tenth-Year</th>
<th></th>
<th>Eleventh-Year</th>
<th></th>
<th>Twelfth-Year</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Athletes</td>
<td>Non-athletes</td>
<td>Athletes</td>
<td>Non-athletes</td>
<td>Athletes</td>
<td>Non-athletes</td>
</tr>
<tr>
<td>Number tested</td>
<td>18</td>
<td>40</td>
<td>28</td>
<td>34</td>
<td>21</td>
<td>24</td>
</tr>
<tr>
<td>Working</td>
<td>11</td>
<td></td>
<td>5</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Late entrant</td>
<td>3</td>
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<td></td>
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<td>Dramatic club</td>
<td>6</td>
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<tr>
<td>Injury</td>
<td>1</td>
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<tr>
<td>Travel</td>
<td>1</td>
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</tr>
</tbody>
</table>

**FIGURE II: Reasons for elimination of certain students from the group to be studied.**

Tabulating the Test Scores

The recorded test scores and questionnaires were used in the following manner.

The raw scores were converted into T scores by means of McCloy's formula and a table was compiled to show the range and distribution of the raw scores and T scores for all six groups. Table I shows the results.

A study of this table discloses several interesting facts. The range of raw scores, from 6 to 135, shows that some girls

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1 Loc. cit., p. 9
<table>
<thead>
<tr>
<th>Class</th>
<th>10th Year</th>
<th>11th Year</th>
<th>12th Year</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>T Athletes</td>
<td>Non-Athletes</td>
<td>T Athletes</td>
</tr>
<tr>
<td></td>
<td>Scores</td>
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<td>Scores</td>
</tr>
<tr>
<td>Raw Scores</td>
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<td></td>
<td>Scores</td>
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<tr>
<td>131-135</td>
<td>72</td>
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<tr>
<td>126-130</td>
<td>69.5</td>
<td>1</td>
<td>68</td>
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<td>121-125</td>
<td></td>
<td></td>
<td>66</td>
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<td>116-115</td>
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<td>11-15</td>
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<td>22.5</td>
</tr>
<tr>
<td>6-10</td>
<td></td>
<td></td>
<td>20.5</td>
</tr>
<tr>
<td>TOTAL</td>
<td>18</td>
<td>18</td>
<td>23</td>
</tr>
</tbody>
</table>

**TABLE I:** Range and distribution of raw scores, and corresponding T scores, on the test of endurance for athletes and non-athletes in the tenth, eleventh, and twelfth year girls' classes in the Gamaliel Bradford High School.
tired very quickly while others were able to continue the finger pull for a long period of time before fatigue became evident.

With only two exceptions, the raw scores and the corresponding T scores were higher for athletes than for non-athletes. The eleventh-year student with the score of 111, the highest in her group, stated that she devotes all of her free time to raising dogs. The girl with a score of 115 in the twelfth-year group chose to direct all of her efforts toward such activities as the class yearbook, the school newspaper, and serving as a class officer. Both were classified as non-athletes.

Establishing and Recording the Correlations

To establish the correlation between the endurance test and success in athletics the test results were used in the following way.

Means were found for the athletes and non-athletes in each class group. The formula \( M = \frac{\sum x}{n} \) was used.

The actual mean and standard deviation were found for the combined group of athletes and non-athletes in each class group.

These means and standard deviations were used in the way prescribed in the formula for biserial correlation\(^1\),

\[ r = \frac{M_2 - M_1}{\sigma} \times \frac{p \cdot q}{\sqrt{y}} \], to determine the coefficient of correlation for each class group.

Table II shows the results of these procedures. This table establishes certain facts. In all three classes the mean for

\(^1\) Loc. cit., p. 10
### TABLE II

<table>
<thead>
<tr>
<th></th>
<th>Sophomores</th>
<th></th>
<th></th>
<th></th>
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</thead>
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<tr>
<td></td>
<td>Athletes</td>
<td>Non-athletes</td>
<td>Athletes</td>
<td>Non-athletes</td>
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<td>Non-athletes</td>
<td>Athletes</td>
</tr>
<tr>
<td>Mean</td>
<td>52.83</td>
<td>46.45</td>
<td>50.19</td>
<td>51.82</td>
<td>46.29</td>
<td>49.14</td>
<td>53.05</td>
</tr>
<tr>
<td>S.D.</td>
<td>10.02</td>
<td>+0.43</td>
<td>9.40</td>
<td>+0.37</td>
<td>+0.44</td>
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**TABLE II:** Correlation of the endurance test and success in athletics as shown by the means of T scores for athletes and non-athletes.
the athletes is higher than the mean for non-athletes. In the tenth-year class the mean for athletes is 52.83 and for the non-athletes the mean is 46.45; in the eleventh-year class the mean for athletes is 51.82 and 46.29 for the non-athletes; in the twelfth-year class the means are 53.05 for athletes and 45.81 for non-athletes.

The actual mean for athletes and non-athletes combined in each class group (50.19 for the tenth-year group, 49.14 for the eleventh, and 49.74 for the twelfth) is approximately midway between the mean for the athletes and the mean for the non-athletes.

The coefficient of correlation for the tenth-year group is .43, for the eleventh-year group, .37, and for the twelfth-year group, .44. In all groups there was a positive correlation.

Although the correlation is not high, the results show that there is some correlation between the test results and athletic success.
CHAPTER IV
CONCLUSIONS AND RECOMMENDATIONS

Conclusions

The following conclusions concerning whether a record of endurance, measured by the ergograph and recorded on the kymograph, could be used as a means of foretelling probable success of high school girls in athletics were drawn from the findings of this study.

In the present day high school girls are being offered a wide variety of extra-class activities. Although a large percentage of high school girls are participating in after school athletics, the girl with a high degree of endurance will not necessarily choose this area, but may prefer to direct her energies toward other activities.

The results of the test showed that endurance will vary greatly among high school girls, and that, in general, athletes have a higher degree of endurance than non-athletes.

Although there is a correlation between the T scores of the endurance test and the athletic participation records, the correlation is not high. Positive correlations of .43, .37, and .44 are not high enough to warrant the use of such a test as the sole means of foretelling probable athletic success.
Recommendations for Further Study

Knowledge and understanding of the capabilities of participants in athletic competition is obligatory for the coaches and physical educators responsible for the competitive activity. Any test which helps to determine those capabilities should be utilized. The endurance test used in this study could well be used for such a purpose.

Physical fitness tests and tests of motor ability abound in the physical education field, but are discarded or ignored by many physical educators because of the time, expense, and complicated equipment involved. If simple, effective and uncomplicated apparatus could be found to test general physical fitness, the problem of testing would be simplified and more generally used. The ergograph used in this study might be just such an apparatus. It is simple and uncomplicated, and each student can be tested in approximately five minutes.

A study to determine the correlation between endurance, as determined by the ergograph, and endurance records in a performance test in a specific skill would establish the effectiveness of its use.

Further use might be made of the test in classifying students in the physical education classes. The person of high endurance might reasonably be expected to attain a high degree of proficiency in physical education activities and, conversely, the person with a low endurance record might be expected to be
less proficient. To establish these facts a study might be made to find the correlation between the ergograph endurance and the recorded marks in physical education classes.
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