1949

A comparison of the results of the Brouha step test and endurance as it applies to high school track athletes

Service Paper

MACDONALD, F.B.

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A COMPARISON of the RESULTS of the BROUHA STEP TEST + ENDURANCE AS IT APPLIES TO H.S. TRACK ATHLETES

Boston University

School of Education

Service Paper

A COMPARISON OF THE RESULTS OF THE BROUHA STEP TEST AND ENDURANCE AS IT APPLIES TO HIGH SCHOOL TRACK ATHLETES

Submitted by

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INTRODUCTION

Recognizing, as a result of much study and research done in the past, that there is a direct relationship between heart rate and physical condition, it is with this thought in mind that there may also be a high degree of relationship between heart rate and endurance.

"Johnson and Brouha[1] have shown that the pulse rates as taken in the Step Test have a significant relation to blood lactate. Men with lower pulse counts after strenuous exercise develop less blood lactate. This verifies the general theory that the cardiac nervous system is a reflex apparatus which automatically regulates the rate of the heart according to the carbonic acid content of the blood. As men train in mile running, their buffer mechanism improves, and they develop less carbonic acid tension for a great effort, hence give slower pulse rates for

[1] A. W. Johnson and Lucien Brouha, "Pulse Rate, Blood Lactate and Duration of Effort in Relation to Ability to Perform Strenuous Exercise," Rev. Canad de Biol. (Feb., 1942).

the same effort. With faster running, the pulse rates recuperate faster because of better and improved respiration."

In this study we will be dealing with two types of endurance and correlating individuals' test scores rather than attempting to show a relationship between one person's score and another's. The first type of endurance is termed muscular and consists of a relatively great amount of strength being demanded over a relatively short period of time. The other is cardiovascular endurance and may be thought of as being quite independent of the muscular type of endurance. It is more closely associated with physical condition than it is with the strength of skeletal muscles.

The army used a variation of the Brouha Step Test to determine the physical condition of convalescent soldiers before sending them back to active duty. It consisted of taking the normal resting pulse rate for one minute, administering the test, recording the pulse rate after the test and noting the length of time it took for the heart to return to normal. Norms were established, and they ruled that a person whose heart failed to return to normal

within a certain period of time was unfit for active service.

[1]"The ability of the heart to do work over the ordinary requirements of the resting state of the body is called its reserve power."

When the heart muscle itself is diseased, it may be so greatly weakened that it cannot, even at maximal dilation, contract forcibly enough to maintain efficient circulation. The signs of heart failure then ensue--breathlessness and the appearance of a bluish tint of the skin, especially of the lips, ears, and fingertips.

It is now generally accepted that a healthy heart cannot be strained by overwork. Athletics, even of a strenuous nature, do not injure a normal heart. On the other hand, if a person with valvular, coronary or other organic cardiac disease indulges in strenuous muscular exercise, serious injury may result.

Marey's law states that the heart rate is inversely related to the arterial blood pressure; in other words, a rise or fall in the arterial blood

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[1]Charles H. Best and Norman B. Taylor, The Living Body, p. 148.

pressure causes, respectively, slowing or acceleration of the heart.

Brainbridge's Reflex is a name given to the increase in heart rate which results from a rise in venous pressure.

It is generally believed that among normal people a low resting pulse and systolic blood pressure, a small increase in both due to moderate exercise and prompt return to normal are characteristic of persons in superior physical condition.

[1]"Human beings tend to operate at a psychological limit rather than a physiological limit in releasing power to act, but what they can do is unbelievably extended under excitement, desperation, and the like."

The post-exercise pulse rate and the increase due to exercise is the most promising indication of those who are in superior physical condition.

[2]"In the light of the relatively scanty evidence available, most of it unpublished, it would

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[1]Hilda Kozman, Rosalind Cassidy, and Chester Jackson, Methods in Physical Education, p, 32.

[2]Charles H. McCloy, Tests and Measurements in Health and Physical Education, p. 134.

seem that endurance of this type is a function not only of strength but of potential velocity of the heart."

An individual might run the 60-yard dash in 6.4 seconds. If he were able to maintain this speed for the 220-yard dash and run it in 21 seconds, his endurance would be considered excellent. But if his time were 26 seconds, his endurance would be poor. For a second individual who might run the 60-yard dash in no faster than 8.0 seconds, a record of 27 seconds in the 220-yard dash would be fast and would indicate a high degree of endurance.

[1]"If fatigue is carried on to the point of absolute exhaustion, the cells do not recover. The protein constituents of the fibers coagulate, exhibiting the phenomen known as rigor mortis. Rigor mortis occurs in muscles from ten to seven hours after death.

[2]Miller's study on the effects of various cadences in the step test indicated an increase in

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[1]Diana Kimber, Carolyn Gray, and Caroline Stackpole, Textbook of Anatomy and Physiology, p. 120.

[2]Waldo A. Miller, "The Effects Upon Pulse Rate of Various Cadences in the Step Test," Research Quarterly (Dec., 1946).

pulse rate which was quite marked from cadences 16 to 27 per minute but tended to level off from 27 to 33 steps per minute. This shows that an increase in speed and effort on the part of an individual will result in a rapid increase in pulse rate up to a certain point, and then the relationship between pulse rate and effort becomes less as the organism approaches its maximum reserve power.

Purpose

This study will fill a gap in needed research in the field of athletics whether the results show a perfect correlation or the other extreme of none, or if it indicates any degree of correlation between the extremes. There have been many studies in which the step test has been employed and others where endurance has been of the main interest, but as yet there have been no studies which attempt to show a relationship between the two.

The findings of this study may be of value to track coaches if it is found that there is a high degree of relationship between the increase in pulse rate as determined by the Brouha Step Test and endurance. The coach might use this test to screen

potential distance runners to determine whether or not they are physiologically suited to this activity.

Selection of Subjects

Track athletes selected for the test are candidates for distance events on the Lowell High School track team. These events include candidates for the 600, 800, 1000 yards, and one mile events.

Some of them are of proven ability because of their performance as members of the team in previous years, and others have never done any competitive running before.

Chapter II

PROCEDURE OF THE STUDY

The tests were administered on the first day the indoor track candidates were called out in order that a relationship between pre-practice condition and practice condition might be noted. The results in all cases, however, will not be valid since some of the candidates were members of the cross-country team and were in training and in fine condition previous to the indoor season. These persons will be discounted in terms of indicating pre-practice and practice condition.

The study extended over a fourteen week period with the test being administered at two week intervals.

After dressing into their track uniforms, candidates selected for the experiment were administered the Brouha Step Test before exercising so that the normal resting pulse rate was obtained.

The Brouha test consisted of taking the normal resting pulse rate after ten minutes of resting in

the sitting position and recording it. Then the subject stepped up and down thirty times a minute on a twenty inch platform. The exercise is continued for five minutes unless the subject stops from exhaustion before the termination of that period. The score is indicated as the increase from the resting pulse rate and the rate after the test has been administered.

The score was not recorded for any boy who failed to complete the test or if the cadence was broken or interfered with in any way.

A stop watch was used to indicate the time, and the cadence was counted by the administrator, since a metronome was not available. Since a cadence of thirty times a minute was used, it necessitated the boy's stepping up and down at a rate of once every two seconds, and the count was up, down, up, down, etc, at a rate of one a second.

The test was administered in a closed room so that extraneous influences would be eliminated as much as possible.

The criteria used to indicate each individual's endurance ratio is his best time for the 100-yard dash.

Since in very short races so much depends on the ability of runners to get a good start and distances over 100 yards are influenced by the element of endurance, it was decided to use the time for the 100-yard dash as a criteria for computing the individual's endurance index. It is believed by the writer that this distance is the best indication of the individual's greatest speed in running.

Each boy was given at least three opportunities on different days to run the 100-yard dash in order that the individual's best time for the distance could be determined.

After allowing the boys to rest and warm up following the administration of the Brouha Step Test, they ran 1000 yards against the clock, and the time at which they passed the 400, 600, 800, and 1000 yard marks was recorded. Each of these times was divided by the time they had previously turned in for the 100-yard dash and totalled. The greater index number indicates a greater drop-off in time from the individual's greatest speed which was indicated by this 100-yard dash time. The lower index score indicates less drop-off in time from the individual's maximum speed, and it can be

said that the runner with the lower index score has greater endurance. We attribute this drop-off in time from the maximum effort as achieved in the 100-yard dash to the influence of fatigue, and it is termed endurance.

Case I
100 yd. dash
14.3

	Dec. 16, 1948	Dec. 30, 1948	Jan. 13, 1949	Jan. 27, 1949	Feb. 10, 1949	Feb. 24, 1949	Mar. 3, 1949
Normal Pulse	84	86	86	84	86	88	84
After Ex.	116	106	108	104	102	100	100
Increase	32	20	22	20	16	12	16
400 yd. time	1:08	1:07	1:08	1:07	1:05	1:04	1:04
600 yd. time	1:47	1:45	1:46	1:44	1:42	1:40	1:41
800 yd. time	2:29	2:26	2:28	2:25	2:21	2:18	2:18
1000 yd. time	3:05.8	3:03.5	3:05.2	2:59.1	2:56.5	2:52.5	2:51.3
Endurance Ind.	35.63	35.05	35.74	33.22	33.83	33.17	33.16

Chapter III

ANALYSIS OF DATA

Case I

This subject was a member of the cross-country team and was in training at the time the indoor candidates were called for practice. In view of this he will not be considered in terms of indicating physiological changes in pre-practice and following practice condition.

On December 16, 1948, an increase in pulse rate of 32 beats per minute was recorded as a result of the Brouha Step Test, and an endurance index of 35.63 was found.

The pulse increase was unusually high and may be attributed to a two week lay off between the end of cross-country practice and the indoor season.

The endurance index at this time was quite good in view of the subject's relatively slow performance in the 1000-yard run. This is due to his slow 100-yard dash time which was used as a divisor and indicates his maximum speed.

On December 30, 1948, the pulse increase was less than that found on the previous test, and the endurance index was greatly improved.

On January 13, 1949, the pulse increase due to the test was higher than on the previous test, and the endurance index was poorer. This may be attributed to a lay off in practice during the Christmas vacation at which time no practice was scheduled for almost two weeks.

On January 27, 1949, less increase in pulse rate and improved endurance index was again recorded.

On February 24, 1949, a similar improvement was recorded over the previous testing.

As a result of the March 3, 1949, testing, an improvement in endurance index was found, but an increase in pulse rate as a result of the step test was recorded. This finding is contrary to the results of the previous testing and goes unexplained.

Case II
100 yd. dash
13.2

	Dec. 16, 1948	Dec. 30, 1948	Jan. 13, 1949	Jan. 27, 1949	Feb. 10, 1949	Feb. 24, 1949	Mar. 3, 1949
Normal Pulse	80	78	82	80	80	78	78
After Exercise	96	88	96	92	90	92	88
Increase	16	10	14	12	10	14	10
400 yd. time	1:03	:59	1:01	1:00	:59	1:01	:59
600 yd. time	1:38	1:32	1:35	1:33	1:33	1:34	1:32
800 yd. time	2:12	2:4	2:09	2:07	2:06	2:08	2:04
1000 yd. time	2:47	2:36	2:41.7	2:40.3	2:39	2:39	2:36.8
Endurance Ind.	34.84	32.62	33.83	33.34	33.12	33.45	32.68

Case II

This subject was also a member of the cross-country team and will be discounted in terms of indicating pre-practice and following practice condition.

The subject was the winner of the 1000-yard run at the interscholastic meet held at Northeastern University and was also New England interscholastic champion in the same event. This accounts for his unusually good endurance index, and it appears that his increase in pulse rate as a result of the Brouha Step Test is exceptionally low.

On December 16, 1948, an increase in pulse rate of 16 was recorded, and his endurance index was 34.84.

On December 30, 1948, an increase in pulse rate of only 10 beats per minute was recorded. This was also accompanied by a decided improvement in his endurance index.

On January 13, 1949, an increase in pulse rate was recorded over the previous testing, and also a poorer endurance index was found. This may be attributed to a two week period at Christmas

time in which no practice was scheduled.

As a result of testing on January 27, 1949, and February 10, 1949, progressive decrease in pulse rate was found, and also progressive improvement in the endurance index was recorded.

On February 24, 1949, the pulse rate showed an increase as a result of the test, and the endurance index was poorer than on the previous testing.

On the final testing administered on March 3, 1949, a decrease in pulse rate was again shown, and a corresponding improvement in the endurance index was recorded.

Case III
100 yd. dash
14.3

	Dec. 16, 1948	Dec. 30, 1948	Jan. 13, 1949	Jan. 27, 1949	Feb. 10, 1949	Feb. 24, 1949	Mar. 3, 1949
Normal Pulse	80	74	78	76	72	86	78
After Exercise	120	102	118	104	92	124	102
Increase	40	28	30	28	20	38	24
400 yd. time	1:12	1:11	1:10	1:09	1:08	1:09	1:10
600 yd. time	1:50	1:48	1:49	1:47	1:45	1:46	1:47
800 yd. time	2:31	2:26	2:28	2:25	2:22	2:23	2:23
1000 yd. time	3:08.7	3:01.2	3:4.1	3:00.5	2:58.4	2:58	2:58.3
Endurance Ind.	36.46	35.39	35.80	35.05	34.49	34.68	34.82

Case III

On December 16, 1948, an increase in pulse rate of 40 was recorded, and the endurance index was 36.46.

A decrease in pulse rate was recorded on December 30, 1948, and an improved endurance index was also indicated.

On January 13, 1949, however, an increase in pulse rate was found with a corresponding increase in the endurance index. This indicates poorer performance but is probably a result of a two week period in which no practice was held.

On February 10, 1949, a lower pulse increase was found than on the previous testing which was accompanied by an improved endurance index.

There was an increase in pulse rate indicated on February 24, 1949, and a poorer endurance index over the previous testing, which is in keeping with the theory behind this study.

The decrease in pulse rate as recorded on March 3, 1949, and the poorer endurance index are contrary to the theory upon which this study

is based. No explanation for this finding is known to the administrator.

Case IV
100 yd. dash
13.1

	Dec. 16, 1948	Dec. 30, 1948	Jan. 13, 1949	Jan. 27, 1949	Feb. 10, 1949	Feb. 24, 1949	Mar. 3, 1949
Normal Pulse	76	74	78	72	70	78	74
After Exercise	120	116	114	110	106	104	98
Increase	44	42	36	38	36	26	24
400 yd. time	1:12	1:10	1:10	1:08	1:07	1:06	1:06
600 yd. time	1:57	1:54	1:51	1:50	1:48	1:41	1:39
800 yd. time	2:34	2:32	2:30	2:25	2:23	2:17	2:15
1000 yd. time	3:13.9	3:08.1	3:01.8	3:03.4	3:00.8	2:53	2:50.2
Endurance Ind.	40.20	39.99	39.13	38.64	38.06	36.38	35.11

Case IV

This case corroberates the belief which prompted this study; that is, a decrease in pulse rate as a result of the step test will be accompanied by greater performance on the part of the athlete in endurance running.

There is, however, one break in this case. This occurred on January 27, 1949, when an increase in pulse rate of two beats per minute was recorded over the previous testing. At this time, continued improvement was found in the endurance index.

This boy was completely inexperienced in competitive running at the first of the season but progressed rapidly so that at the close of the season he was considered one of the better performers of the team. This is indicated by steady improvement in the endurance index, which was 40.20 at the beginning of the season and was 35.11 at the time of the last testing.

The pulse increase as a result of the step test also shows remarkable change. The increase was 44 beats per minute on the first testing and

was almost one-half this number, or 24, at the time of the last testing date.

Case V
100 yd. dash
12.8

	Dec. 16, 1948	Dec. 30, 1948	Jan. 13, 1949	Jan. 27, 1949	Feb. 10, 1949	Feb. 24, 1949	Mar. 3, 1949
Normal Pulse	82	84	88	94	96	90	86
After Exercise	130	126	128	126	128	128	110
Increase	48	42	40	32	32	38	34
400 yd. time	1:08	1:06	1:04	1:02	1:02	1:04	1:03
600 yd. time	1:46	1:42	1:41	1:38	1:37	1:40	1:39
800 yd. time	2:26	2:21	2:19	2:17	2:16	2:18	2:17
1000 yd. time	3:05.3	3:02.9	2:57	2:51.7	2:49.2	2:54	2:51.3
Endurance Ind.	39.38	38.34	37.55	36.62	36.23	37.17	36.72

Case V

On December 16, 1948, an increase in pulse rate of 48 was recorded as a result of the step test, and an endurance index of 39.38 was found.

The next testing period, which was conducted on December 30, 1948, showed a decrease in pulse rate of 6 beats per minute and was accompanied by improved running and better endurance index.

The results of the next testing, conducted on January 13, 1949, brought much the same findings as the previous test. There was a decrease in pulse rate and an improved endurance index.

On January 27, 1949, a decrease in pulse rate of 8 beats per minute was found over the previous testing. This is 16 beats per minute less than was indicated at the first testing period. The endurance index found at this time also indicates improved running over previous testing.

On February 10, 1949, the pulse increase as a result of the step test was the same as on the previous test and was accompanied by a slight improvement in the endurance index.

The results of the February 24, 1949, testing

are interesting in that poorer running was accompanied by an increase in pulse rate over the previous testing. The pulse increase over the last testing period was 6 beats per minute, and the endurance index was considerably poorer than was found on the previous test.

Improvement, or decrease in pulse rate, was found on March 3, 1949, and an improved endurance index was also indicated, which was commensurate with the theory that prompted this study.

Case VI
100 yd. dash
13.6

	Dec. 16, 1948	Dec. 30, 1948	Jan. 13, 1949	Jan. 27, 1949	Feb. 10, 1949	Feb. 24, 1949	Mar. 3, 1949
Normal Pulse	86	82	84	84	88	86	84
After Exercise	130	124	124	120	120	116	106
Increase	44	46	40	36	32	20	22
400 dy. time	1:11	1:10	1:08	1:07	1:04	1:01	1:00
600 yd. time	1:47	1:47	1:44	1:40	1:39	1:35	1:35
800 yd. time	2:30	2:31	2:22	2:19	2:16	2:12	2:12
1000 yd. time	3:06.1	3:08.3	2:57	2:55	2:50.2	2:48.3	2:48.1
Endurance Ind.	37.79	37.84	36.10	35.37	34.41	33.55	33.44

Case VI

On December 16, 1948, a pulse increase of 44 beats per minute was recorded as a result of the step test, and an endurance index of 37.79 was found.

On December 30, 1948, an increase in pulse rate of 2 beats per minute over the previous testing was recorded and was accompanied by a slightly poorer endurance index.

Considerable improvement was found on the next testing date (January 13, 1949) in the endurance index, and there was a marked decrease in pulse increase due to the effects of the step test upon the heart.

Similar improvement continued on the next test which was administered on January 27, 1949. The pulse increase was 4 less than on the previous test, and there was an improved endurance index.

Continued improvement in running was recorded on February 10, 1949, and the pulse increase due to the step test was less than previously found.

On February 24, 1949, a marked decrease in

pulse rate was recorded and was accompanied by nominal improvement in running and endurance index.

There was an increase of 2 beats per minute in pulse rate on the final testing, which is relatively insignificant, and an improved endurance index was recorded.

Chapter IV

SUMMARY AND CONCLUSIONS

The results of this study are not applicable to secondary school boys as a whole but rather to varsity candidates or potential endurance runners on secondary school track teams.

The number of cases studied is too few to warrant definite conclusions. The fact that subjects selected for the study represent boys with considerable native ability excludes the use of the findings from the middle and low ability groups. The conclusions stated indicate general trends only and are applicable only insofar as the cases studied are representative.

This study clearly shows a high degree of relationship between a decrease in pulse rate as a result of the Brouha Step Test and improved running of 1000 yards.

It can be said that if two athletes of relatively equal ability in endurance running were subjected to the step test and the pulse

increase of both was recorded, the one showing the least increase due to the exercise would win in actual competition.

Thus, if a coach has a large group of potential runners and can only use a few of them at a particular time, the step test would serve as a useful device in selecting those who are at present better suited to endurance running. As was previously stated, there are many things that effect pulse rate, and on this basis we can say the athlete who exhibits a low pulse increase due to the standardized step test is better suited physiologically, all other things being equal, to participate in distance running.

There was vast improvement in all the individuals' performances in running during the season as a result of practice, and this was accompanied almost without exception by a decrease in pulse rate as indicated by the step test.

The three exceptions to this rule in forty-two test results cannot of course be pinned down to specific causes, but they may have resulted from

emotional or physiological upset which could not be controlled or diagnosed by the administrator.

A wide variance was found in the resting pulse rate and increase due to the effect of the step test. The lowest resting pulse rate recorded was 70, and the lowest recorded after the exercise was 90. The highest resting pulse rate recorded was 96, and the highest pulse rate recorded following the step test was 130. This shows a variance of 26 beats per minute in individuals before the test was administered and a variance of 40 beats per minute following the administration of the Brouha Step Test.

It is because of this wide difference in individuals' pulse rates that we cannot compare one individual with another. This clearly shows that what is normal for one may be quite abnormal for another. The only indication we might have of showing abnormal pulse rate in this study would be an instance wherein an individual showed marked variance in pulse rate over previous findings.

There are none of these marked changes recorded in this study.

Extremes of Endurance Index Recorded With
Accompanying Pulse Increase Due to the Step Test

	Lowest Recorded Endurance Index	Accompanying Pulse Increase	Highest Recorded Endurance Index	Accompanying Pulse Increase
Case I	33.22	20	35.63	32
Case II	32.62	10	34.84	16
Case III	34.49	20	36.46	40
Case IV	35.11	24	40.20	44
Case V	36.23	32	39.38	48
Case VI	33.44	22	37.84	46

In the preceding chart we can readily see that in the extreme scores for all cases there is a considerable decrease in pulse rate which is without exception accompanied by improved endurance.

It can be said that the testing methods utilized in this study and their findings are not indicative of endurance ability of high school boys when it is used for selecting, from a random sampling of boys, those who are best suited for participation and training in events of endurance.

This test can be employed to indicate present physical condition in relation to activity requiring a high degree of endurance. The primary reason for this is because as men train, their physiological functioning improves and hence give slower pulse rates for the same effort.

Without training, the pulse increase as indicated in the Brouha Step Test will remain high. The pulse rate, therefore, is not a good indicator of potential ability of a boy but may serve a useful purpose in determining present physiological condition.

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A P P E N D I X I

Case I

Peter Toohey
99 Orleans Street
Lowell, Massachusetts
Age 17--Height 66"--Weight 117

Case II

Julian Mroz
59 Fulton Street
Lowell, Massachusetts
Age 18--Height 67"--Weight 135

Case III

Bruce Baxter
57 South Highland Street
Lowell, Massachusetts
Age 18--Height 72"--Weight 158

Case IV

Raymond Armstrong
204 Wentworth Avenue
Lowell, Massachusetts
Age 16--Height 69½"--Weight 165

Case V

James Pawlowski
573 Lawrence Street
Lowell, Massachusetts
Age 17--Height 71"--Weight 170

Case VI

Charles Tewksbury
28 Windsor Street
Lowell, Massachusetts
Age 17--Height 69"--Weight 155

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