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Research on the effect of forced ventilation in the hundred yard dash for junior high school track participants

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RESEARCH ON THE EFFECT OF FORCED VENTILATION IN THE HUNDRED YARD DASH FOR JUNIOR HIGH SCHOOL TRACK PARTICIPANTS

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A C K N O W L E D G E M E N T S

To Dr. James E. Wylie goes my sincere thanks for the time and advice he gave on problems related to this study.

To the Patrick T. Campbell Junior High School track team who cooperated so generously with their time and efforts.

To Joel Freidman, captain of the Campbell track team, who assisted me by acting as starter.

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CHAPTER I

INTRODUCTION

Purpose

The purpose of this study is to determine if it is possible to improve the performance of junior high school track participants by the use of forced breathing.

The author has always been interested in how it was possible to increase ability in track performance with an ergogenic aid.

The author is also curious to know if oxygen can help to delay fatigue in track men. Karpovich says "Forced breathing of ordinary air at the start enriches the lungs with oxygen, and therefore should be helpful, especially before sprinting events".[1]

The author would also like to determine if it is possible to eliminate as much carbon dioxide as is contingent by the use of forced breathing. If this contingency were proved the onset of fatigue would be delayed and the efficiency of the track participant improved.

Justification

Fatigue does set in when the track participant is exercising, and as fatigue sets in, efficiency decreases.

An adequate supply of oxygen is necessary for normal life and activity. It is used by all the cells for oxidative processes in the metabolic changes from which energy is derived. Whenever more energy is required,

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1. Karpovich, P. V., "Ergogenic Aids in Work and Sports," Research Quarterly, American Association Health, Physical Education and Recreation, 12: 432, 1941 (Supplement), p. 16.

metabolism is increased and hence the need of oxygen is also increased.[2]

The capacity of hemoglobin to hold oxygen is very great.[3] It is possible to increase or decrease the respiratory rate within certain limits, by voluntary effort, for a short time. If we arrest the respirations or diminish their frequency, the carbon dioxide concentration in the blood increases, and eventually the stimulus becomes too strong to be controlled. According to some observers, the "breaking point" is reached in twenty-three to seventy-seven seconds. If, before holding the breath, several breaths of pure oxygen are taken, the breaking point may be postponed; or, if the lungs are thoroughly aerated by forced breathing, so that the carbon dioxide is forced out and pure oxygen is breathed in, the breaking point may be postponed as long as eight minutes.[4]

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2. Schneider, E. C. and Karpovich, P. B., "Physiology of Muscular Activity". W. B. Saunders Company, 1948. ch. 4, p. 35.

3. Zoethout, W. D. and Tuttle, W. W.,"Textbook of Physiology". The C. V. Mosby Company, 1946. ch. 13, p. 295.

4. Kimber, D. C., Gray, C. E., and Stackpole, C. E. "Textbook of Anatomy and Physiology." The Macmillan Company, 1946. ch. 17, p.456-457.

CHAPTER II

RESEARCH PROCEDURES

Groups Tested

The majority of boys, who were on the Patrick T. Campbell Junior High School track team for the Spring Season of the school year 1950-1951, were used in this study. These boys were seventh, eighth and ninth graders and their ages varied from thirteen years to fourteen years six months.

All of the Boston junior high outdoor track participants are required to wear indoor track shoes of the type that have no spikes. The purpose of this rule is purely economical. The City of Boston does not supply the junior high school boy with spiked track shoes, consequently the same shoes are used outdoors that are used indoors to insure greater participation. Naturally, many boys would not run outdoors if their parents had to go to the expense of buying spiked shoes. Due to the above facts the times were not as fast as they could have been if the boys had been wearing spikes.

Procedure

In order to standardize the method of forced breathing each boy was instructed to stand at ease in a position of good posture and take his deep breaths in quick succession or with no period of rest between breaths.

Ten and twenty forced respirations were first tried in preliminary experiments but some of the boys were not able to take the twenty forced breaths without approaching a state of giddiness. Consequently the author decided to use only eight and sixteen forced respirations prior to their time trial.

The time trials in this study were recorded during a six week period. The boys were timed on Tuesdays and Thursdays. For the first four weeks the boys ran once on Tuesday and once on Thursday (Eight Series and the Sixteen Series). For the next two weeks the boys ran twice on Tuesday and twice on Thursday (Double Series).

It will be noticed in Table I that the order in which Group A used forced ventilation was reversed for Group B. It was possible that a boy might be stronger on Tuesday than on Thursday or vice versa. Consequently the study was arranged in such a way as to keep these factors as constant as possible.

The boys were divided into two groups; one of nineteen (A) and the other of twenty-two (B). They ran their trials according to Table I.

TABLE I

8 Series

	1st	2nd	3rd	4th
Group A	8FV	NFV	NFV	8FV
Group B	NFV	8FV	8FV	NFV

16 Series

Group A	16FV	NFV	NFV	16FV
Group B	NFV	16FV	16FV	NFV

Double Series

Group A	8FV / NFV	NFV / 8FV	NFV / 8FV	8FV / NFV
Group B	NFV / 8FV	8FV / NFV	8FV / NFV	NFV / 8FV

Forced Ventilation will be represented by the symbol FV. No Forced Ventilation will be represented by the symbol NFV.

A series of runs or any reference to runs in a particular series will be stated in the following manner:

8FV - NFV - NFV - 8FV
= The 8FV Series
NFV - 8FV - 8FV - NFV

16FV - NFV - NFV - 16FV
= The 16FV Series
NFV -16FV - 16FV - NFV

$$\frac{8FV}{NFV} - \frac{NFV}{8FV} - \frac{NFV}{8FV} - \frac{8FV}{NFV}$$

$$\frac{NFV}{8FV} - \frac{8FV}{NFV} - \frac{8FV}{NFV} - \frac{NFV}{8FV}$$

= The Double Series

There were twenty-seven boys out of the forty-one who completed all the Series. The statistical data is based only on the results of the twenty-seven. Their numbers are: 1, 2, 3, 4, 5, 7, 9, 11, 12, 13, 14, 15, 16, 17, 21, 23, 24, 26, 27, 29, 30, 32, 33, 35, 37, 38, 39.

Each boy was required to take the required number of Forced Breaths before the start. As soon as a boy finished his breaths he went on the mark and was started. The distance run was a hundred yards.

The captain of the Campbell track team was the starter and the author was the timer and recorder. This arrangement enabled the experimenters to eliminate as far as possible any human variation in timing and errors in recording.

The boys spent one month in training before their times were taken for this problem. This was to restrict as far as possible improvement due to conditioning. The total group was divided into two groups; one with nineteen boys and the other with twenty-two boys.

The author also instructed the boys to breathe regularly during their runs to keep the oxygen content of the body as constant as possible.

The inclusion of the Critical Ratio in this research shows the signifigance of the data compiled. To be indicative the Critical Ratio computed in this study will have to be above the five per cent level of signifigance for which a Critical Ratio of 1.96[1] is needed.

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1. Garrett, H. E., "Statistics in Psychology and Education", Longmans, Green and Co., New York, 1949. p. 190.

Formula Used[1]

I Standard Deviation

$$SD = \sqrt{\frac{fx'^2}{N} - c^2} \times i$$

II Standard Error of the Mean

$$m = \frac{s}{\sqrt{N}}$$

III Standard Error of the difference between two uncorrelated means

$$D^{\ or} \quad m_1 + m_2 = {}^2m_1 + {}^2m_2$$

IV Critical Ratio

$$CR = \frac{D}{\sigma_D}$$

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1. Garrett, H. E., "Statistics in Psychology and Education," New York, 1949, Longmans, Green and Company, Ch. 3, p. 61, Ch. 7, p. 184, 198, 200.

CHAPTER III

REVIEW OF LITERATURE

One of the limiting factors in physical activities is the amount of oxygen which can be taken up by the organism. Therefore it seems logical to suppose that if one breathes pure oxygen it will increase his capacity for exertion and recovery.

Pembrey and Cook[1] observed that after exercise it was easier to breathe oxygen than air. Hill and Flack[2] reported that when oxygen was given for three minutes immediately before the exercise and also for four to five minutes during recovery, the athletic performance was improved and the recovery from fatigue was quickened. Douglas and Haldane[3] compared the effect of forced breathing of ordinary air with that of quiet inhalation of oxygen, and found forced breathing more helpful than oxygen inhalation before stair-running. Hill and Mackenzie[4] repeated the experiments and found the opposite to be true; Hill and Flack[2] found that a man holding his breath was able to run 470 yards after oxygen inhalation. Moreover, Feldman and Hill[5] noticed that preliminary oxygen inhalation resulted in lower lactic acid accumulation, and also stated that the effects of preliminary oxygen inhalation may last as long as fifteen minutes.

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1. Pembrey, M. and Cook, F., Journal Physiol., 37: XLI, 1909
2. Hill, L. and Flack, M., Journal Physiol., 38: XXVIII, 1909.
3. Douglas, C. and Haldane, J. J., Journal Physiol., 39: I, 1909
4. Hill, L. and Mackenzie, J., Journal Physiol., 39: XXXIII, 1909
5. Feldman, I. and Hill, L., Journal Physiol., 142: 439, 1911

Karpovich[6] found that two minutes after oxygen breathing there was only 20.3 per cent of that gas in the expired air. Miyama[7] reported that preliminary oxygen breathing was beneficial before a 120-m. run and also to recovery after that run. Unfortunately in his test the effect of "warming up" and also "getting used" to peculiarities of the run in a long corridor had not been eliminated. His decisive experiment consisted of testing two men. Both of them ran faster after several trials, whether oxygen was inhaled or not, and the degree of improvement was about the same. Simonson et al.[8] noticed that the effect of preliminary running for about two minutes with moderate speed before a 100-yard dash had a definite beneficial effect. However a preliminary inhalation of oxygen, in spite of some favorable sensation, had no effect upon the speed. Karpovich[6] experimented with a preliminary oxygen breathing immediately before the start in a 100-yard swim. There was definite improvement in speed. Obviously this was due to the ability to hold the breath longer while swimming.

A suggestion has been made that athletes would be able to exert themselves to a greater extent in an atmosphere rich in oxygen. Nielsen and Hansen[9], experimenting with subjects riding bicycle ergometers, found this to be true only when the rate of work became very strenuous.

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6. Karpovich, P. V., Research Quarterly, 5: 24, 1934, (May).
7. Miyama, A., Acta Scholu Med. Univ. imp. in Kioto, 14: 73, 1931.
8. Simonson, E., Orch. of Exp. Pathol. u. Pharmakol, 119: 259, 1927
9, Nielsen, M. and Hansen, O., Skand. Orch. Physiol., 76: 37, 1937

A summary of the literature of the field seems to indicate that oxygen breathing immediately before a short swimming race, during strenuous work, and during the first few minutes of recovery will benefit the individual by improving his performance or quickening his recovery from fatigue. Since there is no storing up of oxygen, the preliminary three deep inhalations of oxygen are just as effective as prolonged breathing; and since the effect of preliminary oxygen breathing wears out in three minutes, there is no basis for the assertion that Japanese victories in swimming were due to oxygen breathing. Forced breathing of ordinary air on the start enriches the lungs with oxygen, and therefore should be helpful, especially before sprinting events.

CHAPTER IV

PRESENTATION OF THE DATA

In tables II to IX the number of cases will be fifty-four instead of twenty-seven because each boy ran twice with forced ventilation and twice without forced ventilation in each of the series.

TABLE II

THE DISTRIBUTION OF TIME SCORES OF TWENTY-SEVEN BOYS WHO USED EIGHT FORCED RESPIRATIONS PRIOR TO RUNNING THE HUNDRED YARD DASH.

Time	Frequency
15.5-15.9	2
15.0-15.4	7
14.5-14.9	4
14.0-14.4	3
13.5-13.9	1
13.0-13.4	8
12.5-12.9	9
12.0-12.4	6
11.5-11.9	9
11.0-11.4	5
	N=54

The mean for these times was 13.6 and the standard deviation was 1.469.

TABLE III

THE DISTIBUTION OF TIME SCORES OF TWENTY-SEVEN BOYS WHO USED NO FORCED RESPIRATIONS PRIOR TO RUNNING THE HUNDRED YARD DASH.

Time	Frequency
15.5-15.9	2
15.0-15.4	7
14.5-14.9	3
14.0-14.4	3
13.5-13.9	3
13.0-13.4	7
12.5-12.9	9
12.0-12.4	4
11.5-11.9	16
11.0-11.4	1
	N=54

The mean for these times was 13.12 and the standard deviation was 7.00.

TABLE IV

THE DISTRIBUTION OF TIME SCORES OF TWENTY-SEVEN BOYS WHO USED SIXTEEN FORCED RESPIRATIONS PRIOR TO RUNNING THE HUNDRED YARD DASH

Time	Frequency
15.5-15.9	2
15.0-15.4	4
14.5-14.9	6
14.0-14.4	4
13.5-13.9	0
13.0-13.4	8
12.5-12.9	9
12.0-12.9	9
11.5-11.9	8
11.0-11.4	4
	N=54

The mean for these times was 13.06 and the standard deviation was 1.469.

TABLE V

THE DISTRIBUTION OF TIME SCORES OF TWENTY-SEVEN BOYS WHO USED NO FORCED RESPIRATION PRIOR TO RUNNING THE HUNDRED YARD DASH.

Time	Frequency
15.5-15.9	4
15.0-15.4	7
14.5-14.9	3
13.5-13.9	2
13.0-13.4	8
12.5-12.9	8
12.0-12.4	6
11.5-11.9	9
11.0-11.4	3
	N=54

The mean for these times was 13.27 and the standard deviation was 1.48.

TABLE VI

THE DISTRIBUTION OF TIME SCORES OF TWENTY-SEVEN BOYS WHO USED EIGHT FORCED RESPIRATIONS FIRST IN THE DOUBLE SERIES PRIOR TO RUNNING THE ONE HUNDRED YARD DASH.

Time	Frequency
15.5-15.9	2
15.0-15.4	7
14.5-14.9	5
14.0-14.4	2
13.5-13.9	1
13.0-13.4	6
12.5-12.9	12
12.0-12.4	6
11.5-11.9	7
11.0-11.4	6
	N=54

The mean for these times was 13.09 and the standard deviation was 1.47

TABLE VII

THE DISTRIBUTION OF TIME SCORES OF TWENTY-SEVEN BOYS WHO USED EIGHT FORCED RESPIRATIONS SECOND IN THE DOUBLE SERIES PRIOR TO RUNNING THE ONE HUNDRED YARD DASH.

Time	Frequency
15.5-15.9	2
15.0-15.4	10
14.5-14.9	1
14.0-14.4	3
13.5-13.9	3
13.0-13.4	6
12.5-12.9	6
12.0-12.4	9
11.5-11.9	12
11.0-11.4	2
	N=54

The mean for these times was 12,88 and the standard deviation was 1.55.

TABLE VIII

THE DISTRIBUTION OF TIME SCORES OF TWENTY-SEVEN BOYS WHO USED EIGHT FORCED RESPIRATIONS SECOND IN THE DOUBLE SERIES PRIOR TO RUNNING THE ONE HUNDRED YARD DASH.

Time	Frequency
16.0-16.4	1
15.5-15.9	5
15.0-15.4	6
14.5-14.9	2
14.0-14.4	2
13.5-13.9	5
13.0-13.4	6
12.5-12.9	9
12.0-12.4	8
11.5-11.9	10
	N=54

The mean for these times was 13.45 and the standard deviation was 1.49.

TABLE IX

THE DISTRIBUTION OF TIME SCORES OF TWENTY-SEVEN BOYS WHO USED EIGHT FORCED RESPIRATIONS FIRST IN THE DOUBLE SERIES PRIOR TO RUNNING THE ONE HUNDRED YARD DASH.

Time	Frequency
16.0-16.4	2
15.5-15.9	3
15.0-15.4	7
14.5-14.9	2
14.0-14.4	2
13.5-13.9	4
13.0-13.4	7
12.5-12.9	9
12.0-12.4	8
11.5-11.9	10
	N=54

The mean for these times was 13.32 and the standard deviation was 2.96.

TABLE X

CALCULATION OF CRITICAL RATIO

8FV SERIES

$$m = \frac{s}{\sqrt{N}}$$

$$m_3 = \frac{1.46}{54} = \frac{1.46}{7.348} = .198$$

$$m_4 = \frac{1.446}{54} = \frac{1.446}{7.348} = .196$$

$$D = {}^2m_1 + {}^2m_2$$

$$D = (.198)^2 + (.196)^2$$

$$D = .039204 + .038416$$

$$D = .077620$$

$$D = .2646$$

$$M_2 = 13.6$$

$$M_3 = 13.1$$

$$.5$$

$$CR = \frac{D}{\sigma D}$$

$$CR = \frac{.5}{.2646}$$

$$CR = 1.89$$

TABLE XI

CALCULATION OF CRITICAL RATIO

16FV SERIES

$$m = \frac{s}{\sqrt{N}}$$

$$m_5 = \frac{1.41}{54} = \frac{1.41}{7.348} = .191$$

$$m_6 = \frac{1.48}{54} = \frac{1.48}{7.348} = .201$$

$$D = {}^2m_1 + {}^2m_2$$

$$D = (.191)^2 + (.201)^2$$

$$D = .036481 + .040401$$

$$D = .076882$$

$$D = .2646$$

$$M_4 = 13.0$$

$$M_5 = 13.2$$

$$.2$$

$$CR = \frac{D}{\sigma D}$$

$$CR = \frac{.2}{.2646}$$

$$CR = .769$$

TABLE XII

CALCULATION OF CRITICAL RATIO

DOUBLE SERIES 8FV AND NFV FIRST

$$m = \frac{s}{\sqrt{N}}$$

$$m_7 = \frac{1.47}{54} = \frac{1.47}{7.348} = .2000$$

$$m_8 = \frac{1.55}{54} = \frac{1.55}{7.348} = .2123$$

$$D = {}^2m_1 + {}^2m_2$$

$$D = (.2)^2 + (.2123)^2$$

$$D = .04 + .044944$$

$$D = .084944$$

$$D = .2828$$

$$M_6 = 13.0$$

$$M_7 = 12.8$$

$$.2$$

$$CR = \frac{D}{\sigma_D}$$

$$CR = \frac{.2}{.2828}$$

$$CR = .714$$

TABLE XIII

CALCULATION OF CRITICAL RATIO

DOUBLE SERIES 8FV AND NFV SECOND

$$m = \frac{s}{\sqrt{N}}$$

$$m_9 = \frac{1.49}{54} = \frac{1.49}{7.348} = .202$$

$$m_{10} = \frac{1.48}{54} = \frac{1.48}{7.348} = \frac{.74}{3.674} = .201$$

$$D = {}^2m_1 + {}^2m_2$$

$$D = (.202)^2 + (.201)^2$$

$$D = .040804 + .040401$$

$$D = .081205$$

$$D = .2828$$

$$M_8 = 13.4$$

$$M_9 = 13.2$$

$$.2$$

$$CR = \frac{D}{\sigma_D}$$

$$CR = \frac{.2}{.2828}$$

$$CR = .715$$

TABLE XIV

THIS TABLE GIVES THE TIME DIFFERENCE BETWEEN FV AND NFV.

Boy	8FV Series	16FV Series	Double Series 8FV and NFV 1st	Double Series 8FV and NFV 2nd
1	-.2	-.3	-.3	0
2	-.2	-.4	-.2	-.1
3	-.2	-.3	-.6	-.1
4	.3	.7	.1	.3
5	-.4	-.2	-.8	0
7	0	0	-.2	.9
9	.2	.4	0	.4
11	0	-.2	-.2	.3
12	-.2	-.2	-1.0	.6
13	.2	.2	-.1	.5
14	-.1	-.2	-1.0	.7
15	.1	.3	.1	.3
16	-.2	-.1	-1.2	.9
17	.4	.5	.4	.6
21	-.4	-.4	-.5	.4
23	.6	0	-.9	.9
24	-.3	-.4	-.9	.8
26	.2	.3	0	.7
27	0	0	-.2	.1
29	-.4	-.4	-.5	-.3

TABLE XIV (continued)

Boy	8FV Series	16FV Series	Double Series 8FV and NFV 1st	Double Series 8FV and NFV 2nd
30	.5	-.2	-.4	.7
32	.3	.4	-.1	.1
33	-.3	-.1	-.2	0
35	-.2	.4	-.7	.9
37	.4	.4	.1	.2
38	-.4	-.6	-1.1	.7
39	0	.4	.1	.2

The figures for Table XIV were determined in the following manner: in the 8FV, 16FV, 8FV first, and 8FV second series, the FV results were added together and the NFV results were added together and the smallest was subtracted from the largest; with positive meaning that the two FV time trials, when added together, were less than the two NFV time trials added together, and negative meaning when the two NFV time trials, when added together, were less that the two FV time trials added together.

The above, simply stated, means that the positive numbers show that FV improved that particular boy's performance and the negative numbers indicate that FV did not help that particular boy's performance.

CHAPTER V

SUMMARY AND CONCLUSION

Summary

The times for the hundred yard dash were taken on forty-one boys, twenty-seven of whom completed the whole series. The statistical data is based on the twenty-seven. Since every boy ran twice for each test there are fifty-four scores for comparison. The significance of obtained differences was tested by calculating a Critical Ratio.

TABLE XV

A COMPARISON OF THE MEAN TIME SCORES OF TWENTY-SEVEN BOYS WHO RAN ONE HUNDRED YARDS WITH AND WITHOUT FORCED VENTILATION.

Number of Forced Respirations	Mean	Standard Deviation	No Forced Ventilation	Mean	Standard Deviation	Critical Ratio
8	13.6	1.469	8	13.12	7.002	1.89
16	13.06	1.417	16	13.27	1.482	.769

The Critical Ratios of 1.89 for the 8FV Series and .769 for the 16FV Series show that they fall below the five per cent level of significance for which a Critical Ratio of 1.96 is needed.

TABLE XVI

A COMPARISON OF THE MEAN TIME SCORES AND CRITICAL RATIO OF TWENTY-SEVEN BOYS WHEN THEY RAN THE FIRST RACE OF THE DAY (DOUBLE SERIES) WITH AND WITHOUT FORCED VENTILATION. A SEPARATE COMPARISON IS MADE OF THE SAME BOYS WHEN THEY RAN WITH AND WITHOUT FORCED VENTILATION IN THE SECOND RACE OF THE DAY.

FV in First and Second Race	Mean	Standard Deviation	NFV in First and Second Race	Mean	Standard Deviation	Critical Ratio
8FV First	13.09	1.474	NFV First	12.88	1.556	.714
8FV Second	13.45	1.491	NFV Second	13.32	2.963	.715

The Critical Ratiosof .714 and .715 for the Double Series show that they fall below the five per cent of significance for which a Critical Ratio of 1.96 is needed.

1. The Critical Ratio found on Table X, is the result of data on the 8FV and NFV in the 8FV Series.

2. The Critical Ratio found on Table XI, is the result of data on the 16FV and NFV in the 16FV Series.

3. The Critical Ratio found on Table XII, is the result of data on the 8FV and NFV First in the Double Series.

4. The Critical Ratio found on Table XIII, is the result of data on the 8FV and NFV Second in the Double Series.

5. A comparison of scores from a positive and negative viewpoint for all the series is found on Table XIV.

The author wanted to see roughly not only what the results were when a Critical Ratio was found but to see also if it is possible for individual cases to benefit by Forced Ventilation.

Conclusions

1. The Critical Ratio of 1.89 found on Table X for the 8FV Series shows that it falls below the five percent level of significance for which a Critical Ratio of 1.96[1] is needed. Therefore, the Null Hypothesis is retained with confidence since on the evidence there is no reason to suspect a true mean difference between 8FV and NFV and the difference can hardly be attributed to sampling errors.

2. The Critical Ratio of .769 found on Table XI for the 16FV Series shows that it falls far below the five percent level of significance for which a Critical Ratio of 1.96[2] is needed. Therefore, the Null Hypothesis is retained with confidence since on the evidence there is no reason to suspect a true mean difference between 8FV and NFV and the difference can hardly be attributed to sampling errors.

3. The Critical Ratio of .714 found on Table XII for the 8FV Series (8FV and NFV First) shows that it falls far below the five percent level of significance for which a Critical Ratio of 1.96[3] is needed. Therefore, the Null Hypothesis is retained with confidence since on the evidence there is no reason to suspect a true mean difference between 8FV and NFV First in the Double Series and the difference can hardly be attributed to sampling errors.

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1. Garrett, H. E., Statistics in Psychology and Education, Longmans, Green and Co., New York, 1949, p. 190.

2. Garrett, H. E., Statistics in Psychology and Education, Longmans, Green and Co., New York, 1949, p. 190.

3. Garrett, H. E., Statistics in Psychology and Education, Longmans, Green and Co., New York, 1949, p. 190.

4. The Critical Ratio of .715 found on Table XIII for the 8FV Series (8FV and NFV Second) shows that it falls far below the five percent level of significance for which a Critical Ratio of 1.96[4] is needed. Therefore, the Null Hypothesis is retained with confidence since on the evidence there is no reason to suspect a true mean difference between 8FV and NFV Second in the Double Series and the difference can hardly be attributed to sampling errors.

5. A comparison of negatives and positives show that the subjects varied from a positive .6 to a negative .4 in the 8FV Series. There are twenty-two boys (1, 2, 3, 4, 5, 9, 12, 13, 14, 15, 16, 17, 21, 24, 26, 29, 30, 32, 33, 35, 37, 38) between positive .5 and negative .5. There is one boy (23) over positive .5 who showed a definite benefit from FV, and no boys who were over negative .5.

In the 16FV Series, the subjects varied from a positive .7 to a negative .6. There are twenty-two boys (1, 2, 3, 5, 9, 11, 12, 13, 14, 15, 16, 17, 21, 24, 26, 29, 30, 32, 33, 35, 37, 39) who are between positive .5 and negative .5; while there is one boy (4) who showed a definite benefit from FV and one boy (38) who was over negative .5.

In the Double Series Second, the boys varied from a positive .9 to a negative .3. There are thirteen boys between positive .5 and negative .5 (2, 3, 4, 9, 11, 13, 15, 21, 27, 29, 32, 37, 39); while there are eleven boys (7, 12, 14, 16, 17, 23, 24, 26, 30, 35, 38) who showed a definite benefit from FV and no boys who were over negative .5.

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4. Ibid.

It must be concluded from Table XIV that each boy must be treated individually. For example, numbers 7, 11, 12, 14, 15, 21, 24, 27, and 38 ran with negative results until they used FV First in the Double Series then they had a positive result. Therefore, these boys should use FV when running more than two races at approximately one hour apart. Each boy has to be tested to determine whether 8FV, 16FV and 8FV Second is best for that individual.

Possibilities of Further Research

There are many possibilities of further research in this area. The various events in track are available for this type of experimentation. Not only Forced Ventilation but also pure oxygen could be used in these experiments.

The research could also be limited to having the contestants either hold their breath or continue breathing during the race.

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APPENDIX

RAW DATA

TABLE XVII

Group A			Eight Series	
No.	8FV	NFV	NFV	8FV
1	11.5	11.5	11.4	11.6
2	15.2	15.2	15.0	15.2
3	12.2	12.2	12.1	12.3
4	11.4	11.7	11.5	11.5
5	12.7	12.5	12.5	12.7
6	14.2	-	-	-
7	15.8	15.8	15.7	15.7
8	14.3	14.2	14.1	14.2
9	11.5	11.6	11.6	11.5
10	15.3	15.4	15.3	15.4
11	13.0	13.1	13.0	13.1
12	12.8	12.7	12.6	12.7
13	12.5	12.6	12.7	12.6
14	13.2	13.1	13.2	13.2
15	15.0	15.1	15.1	15.1
16	14.9	14.9	14.8	15.0
17	13.5	13.7	13.6	13.4
18	14.2	14.2	14.1	14.2
19	12.2	11.9	11.9	11.9

TABLE XVIII

	Group B		Eight Series	
No.	NFV	8FV	8FV	NFV
20	12.1	12.2	12.3	12.
21	12.	12.2	12.3	12.1
22	14.3	14.	14.	14.2
23	11.8	11.6	11.5	11.9
24	11.7	11.8	11.9	11.7
25	15.2	15.3	-	-
26	11.5	11.4	11.4	11.5
27	12.6	12.5	12.6	12.5
28	11.6	11.5	11.4	-
29	13.9	14.2	14.1	14.
30	11.6	11.3	11.3	11.5
31	14.7	14.7	14.6	14.7
32	13.4	13.3	13.1	13.3
33	11.9	12.	12.1	11.9
34	15.1	15.	-	-
35	14.9	15.	15.1	15.
36	13.5	13.5	13.6	13.4
37	15.1	14.9	14.8	15.
38	14.3	14.4	14.5	14.2
39	12.9	12.9	13.	13.
40	12.	11.7	11.8	11.9
41	11.3	11.3	11.4	11.3

TABLE XX

	Group B		Sixteen Series	
Subject	0	16FV	16FV	0
20	12.4	12.2	-	-
21	12.1	12.3	12.2	12
22	-	-	-	-
23	11.9	11.6	11.9	11.6
24	11.8	12.	11.9	11.7
25	-	-	-	-
26	11.6	11.5	11.5	11.7
27	12.5	12.4	12.5	12.4
28	-	-	-	-
29	14.1	14.3	14.4	14.2
30	11.3	11.4	11.5	11.4
31	15.	15.1	-	-
32	13.3	13.	13.1	13.2
33	12.1	12.1	12.1	12.
34	-	-	-	-
35	15.1	14.9	14.8	15.
36	-	-	-	-
37	14.9	14.8	14.7	15.
38	14.	14.4	14.4	14.2
39	13.1	12.8	12.9	13.
40	-	-	-	-
41	11.5	-	-	-

TABLE XXI

Group A			Double Series	
Subject	8/NFV	NFV/8	NFV/8	8/NFV
1	11.6 11.6	11.4 11.6	11.5 11.6	11.7 11.7
2	15.3 15.2	15.3 15.4	15.4 15.5	15.3 15.3
3	12.1 12.1	12.1 12.5	12.2 12.4	12.2 12.1
4	11.4 11.5	11.5 11.4	11.4 11.4	11.3 11.5
5	12.7 12.8	12.4 12.7	12.5 13.0	12.8 12.7
6				
7	15.7 16.1	15.9 16.	15.8 15.9	15.7 16.2
8				
9	11.4 11.6	11.5 11.5	11.6 11.6	11.4 11.6
10				
11	12.9 13.	13. 13.1	12.9 13.2	13. 13.2
12	12.8 13.1	12.6 13.1	12.7 13.2	12.9 13.2
13	12.5 12.7	12.6 12.6	12.7 12.8	12.5 12.8
14	13.4 13.9	13.3 13.9	13.3 13.7	13.5 13.7
15	15.0 15.2	15.1 15.1	15.4 15.3	15.0 15.1
16	14.9 15.6	15. 15.7	15.1 15.6	15.2 15.4
17	13.4 13.7	13.6 13.5	13.5 13.2	13.2 13.5
18				
19				

TABLE XIX

Group A	Sixteen Series			
Subject	16	0	0	16
1	11.6	11.4	11.5	11.6
2	15.3	15.1	15.0	15.2
3	12.3	12.1	12.1	12.2
4	11.4	11.7	11.8	11.4
5	12.7	12.6	12.5	12.6
6	-	-	-	-
7	15.7	15.9	15.8	15.6
8	14.4	-	-	-
9	11.3	11.5	11.6	11.4
10	15.2	-	-	-
11	13.2	13.1	13.1	13.1
12	12.7	12.6	12.7	12.8
13	12.5	12.6	12.6	12.5
14	13.3	13.2	13.3	13.4
15	15.0	15.2	15.1	15.0
16	14.9	14.8	14.8	14.8
17	13.4	13.6	13.7	13.4
18	14.4	14.2	14.3	-
19	17.0	11.9	11.9	-

TABLE XXII

Subject	Group B NFV/SFV	SFV/NFV	Double Series SFV/NFV	NFV/SFV
20				
21	12.1 12.3	12.2 12.4	12.3 12.5	12.1 12.4
22				
23	11.9 12.4	11.7 12.1	11.5 12.0	11.9 12.3
24	11.8 12.3	11.9 12.4	12. 12.3	11.7 12.1
25				
26	11.6 11.6	11.5 11.9	11.5 11.8	11.7 11.7
27	12.4 12.5	12.5 12.5	12.7 12.8	12.4 12.5
28				
29	14. 14.2	14.2 14.1	14.3 14.1	14. 14.3
30	11.6 11.8	11.3 11.7	11.4 11.7	11.6 11.8
31				
32	13.4 13.5	13.2 13.2	13.3 13.4	13.5 13.5
33	12.3 12.3	12.5 12.4	12.4 12.5	12.4 12.6
34				
35	15.2 15.6	15.4 15.9	15.3 15.7	15. 15.3
36				
37	15. 15.	14.8 14.9	14.9 15.	15. 14.9
38	14.3 14.9	14.5 14.8	14.7 15.1	14.6 15.1
39	13. 13.	12.9 13.	12.8 12.9	13. 12.9
40				
41				