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Effects of Sodium Phosphate on the Performance of Track Athletes on the 660-Yard Run

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EFFECTS OF SODIUM PHOSPHATE ON THE PERFORMANCE OF TRACK ATHLETES ON THE 660-YARD RUN

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TABLE OF CONTENTS

CHAPTER		PAGE
I.	THE PROBLEM AND DEFINITION OF TERMS USED	1
	Introduction	1
	The Problem	1
	Statement of the problem	1
	The hypothesis tested	2
	Justification of the study	2
	General method of procedure	2
	Limitations of the study	3
	Definitions of Terms Used	3
	Drop-off index	3
	Heartometer	4
	Systolic pulse wave amplitude	4
	Heartograph	4
	Placebo	4
	Overview of Remainder of Thesis	4
II.	REVIEW OF THE LITERATURE	5
	Ergogenic Aids	5
	Administration of Phosphates	7
	Performance Test	9
	Drop-Off Index	10
	Cardiovascular Test	12
	Validity of heartographs	17
	Reliability of the heartometer	20

CHAPTER		PAGE
III.	PROCEDURE	22
	Preliminary Steps	22
	Grouping	22
	Salt Administration	24
	Cardiovascular Test	25
	660-Yard Run	26
	Training	27
IV.	ANALYSIS OF DATA	28
	Analysis of Drop-Off Index	28
	Analysis of the Running Times	29
	Hypothesis	29
	Results	29
	Analysis of Heartograph	30
V.	SUMMARY	33
	Results	34
	Conclusions	35
	Recommendations	35
BIBLIOGRAPHY		36
APPENDIX A.	Rank Order of Subjects	41
APPENDIX B.	Method Used for Equating Groups	42

LIST OF TABLES

TABLE		PAGE
I.	Drop-off Indexes Calculated from World's and American Championship Records	11
II.	Reliability of Heartometer Measurements	21
III.	Active Ingredients per Tablet of the Sodium Phosphate	24
IV.	Testing Dates	26
V.	The *t* Ratio of the Three Groups on the Drop-off Index	28
VI.	Comparisons of Means Between the Three Groups on the Four Tests of the 660-Yard Run	31
VII.	The *t* Ratios of the Three Groups on the Four Tests of the 660-Yard Run	31
VIII.	The *t* Ratios of the Three Groups on Eight Items of the Heartometer Pulse Wave Test	32

LIST OF FIGURES

FIGURE PAGE

1. Cardiac Cycle With Circulatory Phenomena
 Portrayed 15

CHAPTER I

THE PROBLEM AND DEFINITION OF TERMS USED

I. INTRODUCTION

During the coaching clinic of the 1967 National Collegiate Athletic Association Track and Field Meet, Ralph Tate, track coach at Oklahoma State University, indicated that high school track athletes to whom he has administered sodium phosphate seemed capable of greatly increased amounts of work during training, which perhaps was responsible for improved performances. It was also observed that the athletes did not experience muscular soreness with the increase in work and speculated that this might be useful in the prevention of muscle strains.

Studies have been conducted to determine the effect of phosphates on the working capacity of various groups and the evidence indicates that phosphate preparations are definitely beneficial. However, there is no available evidence in the literature as to the effectiveness of the administration of phosphates to improve performances in the area of athletics.

II. THE PROBLEM

Statement of the problem. The problem of investigation was to determine whether the use of sodium phosphate during training improved the performance of track athletes on the 660-yard run.

The hypothesis tested. Sodium phosphate improves the performance of track athletes on the 660-yard run, by a margin statistically significant at the .1 level of confidence, over other groups not using the sodium phosphate.

Justification of the study. The importance of this investigation was based on the possible improvement of track athletic performance due to the use of sodium phosphate during training. It may be especially important to individuals or teams with restricted season length, which imposes conditioning difficulty due to the limited time. Furthermore, if sodium phosphate aids in the prevention of muscle strains, by means of preventing muscle soreness during training it may be beneficial to athletes for the prevention of muscle damage and unnecessary restriction from participation.

General method of procedure. The East Valley High School Track Team of the Moxee School District was used to conduct the study. The team was subjected to three weeks of early season conditioning (March 4, 1968 to March 21, 1968), after which the subjects were tested for an endurance factor and placed into one of three study groups. The experimental group was then administered sodium phosphate for a period of six weeks, the placebo control group was administered milk sugar, and the control group was not administered anything.

At two week time intervals, the individuals of each group were timed at the 660-yard run and a post study Heartograph recorded. The means and *t* ratios of the times and the Heartometer readings were compared in an attempt to determine a significant difference between the study groups.

Limitations of the study. The limitations of the study are as follows:

1. The motivational-attitude of the subjects toward the training program over the length of the study varied greatly.
2. The effect of sodium phosphate on training during the first three weeks of the season was not measured because of the need for preliminary training in preparation for the grouping procedure used in this study.
3. The study was limited to six weeks because of the end of the competitive season for the junior varsity subjects.
4. The effects of a variation of the dosage was not possible due to a limit of available subjects.

III. DEFINITIONS OF TERMS USED

Drop-off index. An endurance index which shows the subject's ability to maintain short run speed over a longer run.

Heartometer. A device that provides a graphic record of cardiovascular functions by means of measuring lateral pressure changes in the arteries.

Systalic pulse wave amplitude. The magnitude of the contractions by the ventricle of the heart as measured by the heartometer. It is the first and highest deflection of the heartograph cycle.

Heartograph. A visual recording of the cardiovascular functions as measured by the heartometer.

Placebo. A tablet prepared from milk sugar used to imitate the sodium phosphate tablets.

IV. OVERVIEW OF REMAINDER OF THESIS

Chapter II contains a review of the literature pertaining to the thesis problem. Chapter III contains the procedures used in this investigation of the thesis problem, including statistical methods. Chapter IV contains the results of the thesis problem, involving the evaluation of the data collected. Chapter V contains the summary, conclusions, and suggested recommendations found through the evaluation of the results of the study.

CHAPTER II

REVIEW OF THE LITERATURE

Examination of the literature revealed limited research in the administration of phosphate preparations to improve working capacity and none in relation to athletics. For this research, related studies concerning the administration of phosphates and the measurement of endurance improvement during training were reviewed.

I. ERGOGENIC AIDS

In athletic situations where a high state of physical fitness, including endurance, is of great importance, the question of various aids to conditioning are important. As these conditioning aids are introduced and made available, they must be carefully scrutinized as to their effect on the sport and individual.

In many cases the investigator of such aids is affected by a wave of enthusiasm and the result is a poorly controlled investigation which gives unwarranted support to the value of the aid (18:432-433). Karpovich wrote the following concerning the investigation of such aids:

> On the surface it may seem simple to determine the effect of some substance upon muscular performance merely to test the subjects before and after the administration of the substance in question. This may be sufficient in some cases in which the effect of a big dose of a powerful

> drug is tested, but in most cases the doses are relatively small, and their effects are not obvious. The common error in many investigations is the absence or inadequacy of control in the experiments. The practical men--athletes and their coaches--are especially guilty whenever they ascribe success in games to the use of some substance. The weakness of such assumptions is evident. There are so many factors involved in sports which require skill and team coordination, as well as changes in team personnel, that it is practically impossible to discern the effect of any substance in question upon the team performance.
>
> In the case of measurable events such as swimming or track and field sports, it still is not easy to discover the effect of some supposed aids upon performance. One should make allowance for the influence of training, of excitement, and of unpredictable and inexplicable changes in the athlete which make him excel one day and fail another. Results obtained during contests should be compared with experiments made during time trials. Sham tests in which, instead of the "real stuff", inert substitutes are given should be employed, and the psychological factors should be controlled as much as possible (18:433).

The ethical use of aids to improve physical performance must be considered to prevent any group or individual from obtaining an unfair advantage. Karpovich (18:433) wrote that the use of a substance or device which improves the physical performance of a man without being injurious to his health is not unethical. To the question of taking advantage of other contestants who do not use the aids, he indicates this should be regarded in the same manner as special diets, massage, etc. If these means are available to everyone and they may be used if so desired, they should not be considered unethical. Karpovich (18) included phosphates in his list of ergogenic aids which was compiled in relation to this discussion of ethics.

II. ADMINISTRATION OF PHOSPHATES

The majority of evidence favors the idea that phosphate preparations are beneficial to working capacity. Yet there is no definite proof that the administration of phosphates is responsible for improved performance in athletics (28:310).

The belief that the administration of phosphate preparations may be beneficial to athletics seems to be substantiated by the fact that phosphate compounds are essential to physical activity because the break-up of phosphate compounds in the body supplies the energy for muscular contraction (25:186-190). This is substantiated by Schneider who indicated that phosphates are involved in the metabolism of sugars in the body and said there is reason to believe that phosphated sugar is more available for immediate use than ordinary glucose sugar. Immediately after muscular activity, the inorganic phosphates of the blood are high but quickly fall below normal. The explanation of this is that in the process of recovery the muscles use the blood phosphates to manufacture phosphated sugar. It is obvious that a shortage of phosphates in the blood would handicap the muscles in their recharging (28:134).

Schneider and Karpovich (28:134-135) cited work by Havard and Reay comparing the blood phosphate level of trained and untrained subjects. The following shows their findings:

> Havard and Reay have shown that there is a marked difference in the blood content of phosphates after a given exercise in the trained and the untrained man. After a given exertion the phosphates of the blood in the trained man do not fall so low as in the untrained man. It is suggested that during the progressively increasing activity of a muscle brought about by training, a larger amount of the phosphated sugar is laid down in the muscle. It is often nature's way to overcompensate when a repair is made in the body. So it is with the muscle: after a burst of exercise by an untrained muscle a larger demand for phosphate is made, because the muscle then forms more phosphated sugar than has been broken down. A well trained muscle very likely already contains a maximum amount of these substances and, therefore, manufactures less than the untrained in the recovery of recharging process (28:134-135).

This reasoning may have some implication to the usefulness of sodium phosphate in athletic training, however the training involved in track performance may be continually taxing to the blood phosphates and not level off as implied by the former reasoning.

In addition to phosphates being a source of energy for muscle activity, they also act as buffers to acids in the body generally associated with impairing sustained muscle activity. (25:186-190) Embden verified this by showing that a phosphated sugar is the immediate precursor of the lactic acid which appears in muscle during exercise (28:134 citing 9).

Embden conducted research using sodium phosphate and reported a twenty per cent increase in working capacity in ergometric tests. He reportedly used sham feeding to eliminate any psychological effect and obtained the results with daily doses of three grams. It was found that larger doses may cause insomnia and other disturbances (18:443-444 citing 9).

Schneider (28:309) indicates Puni confirmed much of Embden's work and found that a small dose of phosphate taken one to three hours before a psychomotor or motor test increased the endurance of the subjects.

Reabuschinsky also reporting on the effect of phosphate consumption for work showed that the amount of work accomplished was considerably increased by taking sodium phosphate in amounts sufficient to approximately double the daily phosphorous intake (28:308-309 citing 25).

III. PERFORMANCE TEST

Hall studied the endurance of Illinois 4-H Club members who participated in a field day from 1943 to 1949. During the first two years the study utilized the one thousand yard run as an endurance test. Since participation in the event was limited to approximately 35 per cent of the members, the distance was changed to six hundred yards. Participation rose to 95 per cent over the next four years and Hall concluded the 600-yard run to be a satisfactory distance for those who are in fair condition (13:37-49).

Flanagan (10:46-50) and Henry (17:32-46) utilized the 220-yard run as the criterion for speed endurance which was being correlated with a pulse-ratio test. It was concluded that the speed element in the 220-yard run was too great to be a valid measure of endurance. This was clearly illustrated by Hall (13:43) when he compiled a list of world and American running records. Examination of Table I indicates that the 200 meters, which is approximately 220 yards, is run with the greatest speed of all distances commonly run from 54.8 meters to 1000 meters at the level of international competition. See Table I on page 11.

IV. DROP-OFF INDEX

The drop-off index has been utilized to measure the fatigue factor in various endurance events. Cureton (4:106-112) utilized a drop-off index to measure relative endurance of swimmers and found a .74 correlation of the index to the McCurdy-Larson Organic Endurance Test. Flanagan (10:46-50) also calculated a quotient index, utilizing runs of sixty yards and 200 yards as a measure of endurance in sprint running.

Henry and Kleeburger (17:32-46) designed a different endurance index for cardiac efficiency. Their index included a body weight factor since they were concerned with the work output of their subject. $\left(Q = \frac{1000 \text{ yards} \times \text{weight} \div \text{time}}{100 \text{ yards} \times \text{weight} \div \text{time}}\right)$

Hall (13:42) converted the formula to the following:

$$\text{Drop-off} = \text{Time Ratio} \left(\frac{\text{Long Run}}{\text{Short Run}}\right) \div \text{Distance Ratio} \left(\frac{\text{Long Run}}{\text{Short Run}}\right)$$

TABLE I

DROP-OFF INDEXES CALCULATED FROM WORLD'S AND AMERICAN CHAMPIONSHIP RECORDS

Distance Meters	Time Sec.	Speed M/sec	Ratio X/200	Drop-off Index
54.8	6.0	9.133		
60.0	6.6	9.090		
91.4	9.4	9.723		
100.0	10.2	9.804		
200.0	20.3	9.852	1.00	1.00
201.6	20.5	9.834	1.01	1.01
274.3	29.8	9.205	1.37	1.08
300.0	33.2	9.036	1.50	1.09
400.0	46.0	8.696	2.00	1.14
402.3	46.4	8.670	2.01	1.14
500.0	63.4	7.886	2.50	1.25
548.6	69.2	7.928	2.74	1.25
600.0	78.9	7.605	3.00	1.30
800.0	108.6	7.366	4.00	1.33
804.7	109.6	7.342	4.02	1.35
914.4	129.3	7.072	4.57	1.39
1000.0	149.6	6.684	5.00	1.47

The weight factor was dropped by Hall since he was concerned only with a measure of endurance.

The ratios of the run lengths used in the Drop-off Indices has varied greatly according to the purpose of the study. Hall reasoned that the drop-off was designed as an endurance index and consequently both run lengths should involve an endurance factor. The 60- and 100-yard runs used in some studies demand little in endurance and furthermore, they are not run as fast as 220 yards. Runs longer than six hundred yards had discouraged high participation by 4-H Club members. For these reasons Hall decided to use a two hundred-six hundred yard combination (13:43).

It is necessary that the subjects do their best on the short run as well as the long run in order to arrive at a valid index. In order to determine the minimum expected scores when runners were doing their best, Hall (13:43) used the American and world records shown in Table I to calculate drop-off indices. The index for the two hundred-six hundred meter ratio was found to be 1.30.

V. CARDIOVASCULAR TEST

The Cameron Heartometer was utilized in this study as a means of measuring cardiovascular phenomena. The literature accompanying the Heartometer, "based on special research in physical education at the University of Illinois Urbana, under direction of Dr. T. K. Cureton" (3:5), includes technical information concerning the use and function of the device.

The Heartograph measures a combination of blood vessel suppleness and energy of the blood stream. The blood flow in terms of minute volume and also the stroke volume are quite proportional to certain measurements made on the Heartograph by careful quantitative procedures.

The Heartograph is truly representative of certain aspects of heart actions, which when transmitted to the blood vessels, reflect through pressure changes, pulse rate, as well as the timing of the systole and diastole, the velocity of the systolic action, and speed of the "drain off" of the blood from the aortic tree and the timing of the valve actions.

The main flow of blood can be considered as proportional to the cuff pressure changes caused by fluctuation in the artery under the cuff, and also some of the other aspects which are strongly associated with body position, fatigue, circulatory fitness and performance in sports, i.e., especially endurance.

Also, and very important, the Heartograph reflects the tone and quality of the large arteries, such as the brachial artery. A very strong heart may be quite inadequate in achieving good circulation for a subject if the peripheral resistance of the small arterioles and capillaries is exceedingly high, or if the veins have lost their tone so that blood cannot be efficiently returned to the heart or if the main arteries are relatively thick and non-elastic and non-resilient because of age or poor condition. The Heartograph reflects such changes by strong or weak pulse waves, giving proportionate measures of this very important type of fitness. It is believed that physical training greatly affects the tone and condition of the blood vessels, thereby permitting the heart to do its work easily and permitting more blood flow (and oxygen) to reach the muscles (3:5-6).

The Heartometer picks up the lateral pressure changes in the arteries and translates those into a graphic record. This extra-arterial pressure is not the same as the pressure within the heart itself or even within the blood stream at a given point because it is modified to some degree by the condition of the blood vessels to transmit the pressure changes from within the vessels to the graph.

Since the blood that can be passed on effectively to the muscles, this characteristic suppleness and elasticity of the large blood vessels, is a very important characteristic of physical fitness (3:6).

A sample of a cardiac cycle portrayed pictorially is shown in Figure 1.

The cycle is composed basically of two phases of action by the heart--the systolic (ejection) phase and diastolic (filling) phase (5:232-280).

The vertical amplitudes of the cycle are proportional to the energy of the pulse wave, while the horizontal measurements are functions of time (3:15). As subjects have been trained toward better endurance performances, the ejection increases in amplitude and the diastolic lengthens in time as compared to the ejection phase (5:232-280).

Several characteristics of the pulse wave are suitable for measurement and their physiological interpretations have been described by Cureton (5) and the Cameron Heartometer Company (3).

<u>AREA UNDER CURVE</u> - (ABDHCA) The area reflects somewhat the blood pumped per stroke of the heart and also the tone of the wall in the Brachial artery and its branches.

<u>SYSTOLIC PULSE WAVE AMPLITUDE</u> - (AB) This measurement indicates the magnitude of the myocardial action due to the contraction of the ventricles. It is the first and highest deflection of the Heartograph cycle.

<u>DICROTIC NOTCH AMPLITUDE</u> - (ED) This indicates the level of cardiovascular tone, i.e., it is proportional to the diastolic blood pressure which acts as back pressure to close the semilunar valves. If the elastic rebound of the aorta and other principal vessels is

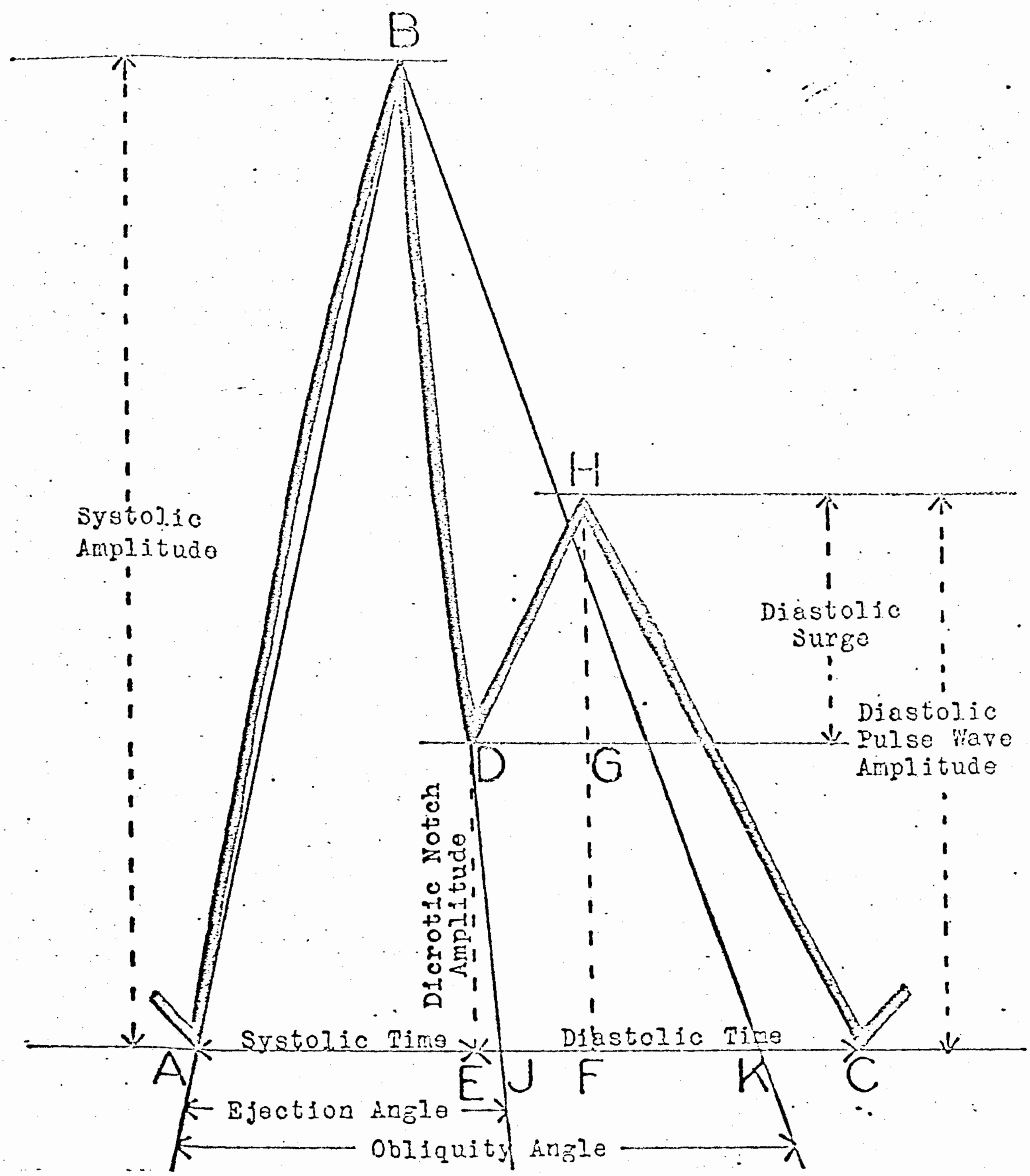

FIGURE 1

CARDIAC CYCLE WITH CIRCULATORY PHENOMENA PORTRAYED relatively strong, the pressure is transmitted mechanically through the blood to close the semilunar valves quickly.

FATIGUE RATIO - (DE/AB) The ratio of the diacrotic notch amplitude to the systolic amplitude. The slower the valves close, the greater the fatigue or apprehension, which is indicated by lower diastolic blood pressure acting to snap the valves shut and consequently, the height of the docrotic notch is lower than normal.

OBLIQUITY ANGLE - (ABK) This is the angle made by AB and a line drawn from B to the center of the Heartograph. The significance of the angle of obliquity may be in the fact that a slow acting heart muscle, due to weakness or to sluggish heart tissue, gives a greater angle because more time is taken for the upward systolic stroke to the maximum point.

EJECTION ANGLE - (ABJ) As previously stated, the ejection angle has even better physiological interpretations.

PULSE RATE - This is the pulse rate taken in beats per minute from the Heartograph by counting the beats on the graph for 15 seconds then multiplying by four. The fractional part of the beat is estimated to the nearest tenth of a beat by inspection before multiplication. A slow pulse rate is fairly highly correlated with endurance performance in track running.

SINGLE CYCLE TIME - (AC) This is an alternate measurement for rate.

DIASTOLIC PULSE WAVE AMPLITUDE - (FH) The part of the total Heartograph in a single cycle which occurs after the semilunar valves close is represented by the diastolic pulse wave. It is measured by the vernier calipers from the peak of the diastolic (dicrotic) wave to the base line of the cycle selected, parallel to the blue lines radiating from the center.

DIASTOLIC SURGE - (GH) The amplitude of the "hump" or dicrotic wave which shows a second upward stroke similar to the original systolic stroke and coming just after the lowest point of the dicrotic notch is a most important component. It seems to be caused by the reflected pressure wave from the semilunar valves and possibly by active contraction of the aorta after the semilunar valves close. Part of it is no doubt due to elasticity of the aorta, but the aorta contains smooth muscle which seems to develop an active function in athletic subjects.

TIME OF DIASTOLE - (EC) The horizontal measurement taken with the vernier calipers from the dicrotic notch to the end of the cycle. It measures the time of the diastole from the closing of the semilunar valves. The measurement is taken in linear centimeters and hundredths for convenience without conversion to seconds.

TIME OF SYSTOLE - (AE) The measurement is taken horizontally from the start of the systole to the close of the semilunar valves. The result is proportional to the time of systole and is taken in linear centimeters and hundredths for convenience without conversion to seconds. Alone, it is of limited value, but it is used with the Fatigue Ratio.

REST TO WORK RATIO (Diastolic Time/Systolic Time) - (EC/AE) This is the ratio of the systolic contraction time (from the start of the systolic stroke to the point of closing of the semilunar valves) to the over-all time of the diastole (from the point of closing of the semilunar valves to the start of the next systole).

Validity of Heartographs

The ability of the Heartometer to predict various states of condition during training has been investigated and reported by the Cameron Heartometer Company (3). Much of their information is based on the research of Cureton and his associates. The results of the research are summarized by the following statement in the Cameron manual:

> Over several weeks of training the endurance improves and the Heartography typically increases in both systolic and diastolic amplitude, diastolic surge, area; also the ejection angle and angle of obliquity become smaller and the ratio of rest to work increases. These measures all correlate with increased stroke output and minute volume by other laboratory procedures, but the Heartograph measures are more reliable (consistent) than the measures of stroke volume and minute volume, for the latter do not include the characteristics of the walls of the blood vessels. Many experiments have clearly shown the progressive improvement of the Brachial Pulse Wave factor

during training programs extended over several weeks. Conversely, progressive deterioration of cardiovascular condition is associated with poorer heartograph measures; and fatigue also produces similar lowered measures. It is therefore certain that the tone of the larger arteries and the blood flow are reflected in the Heartograph (3:11).

The above statement is given support by findings of statistical validity cited by Cureton in his book entitled Physical Fitness of Champion Athletes. The following includes some of those results.

Willet used 65 young men to correlate the following pulse wave items to an all-out treadmill run. Recordings were made with a standardized cuff pressure of 80 mm. Hg. (6: 233)

Diastolic Pulse Wave Amplitude	.491
Systolic Amplitude	.404
Obliquity Angle	-.357
Area	.504

In another study 29 basketball players and track runners were tested on the all-out treadmill run and the following validity coefficients were obtained (6:232).

Obliquity Angle	-.480
Area	.448
Dicrotic Amplitude	.404
Fatigue Ratio	.336

The prediction value was also illustrated by studies dealing with swimmers. A standard score equation composed of systolic pulse wave amplitude, diastolic surge amplitude and angle of obliquity was as high as R = .607 in the prediction of fifteen men of championship condition from 109 men of average condition (6:233).

Tosky (3:14-15) used sixteen different methods to compare the prediction value of cardiovascular efficiency. All findings were correlated and checked against an all-out treadmill run criterion. The Heartometer findings, Area 4/S.A. (surface area of the body) proved to be the best single measure.

Investigations reported by many researchers as to the characteristics of pressure pulse waves of athletes compared to non-athletics are statistically confirmed. It is noted, however, that changes due to training are less than the pre-existing differences and only of borderline statistical significance. Henry concluded from his investigation that the decrease in heart rate is a more effective test of changes in athletic condition, whereas the Heartographs primarily differentiate successful athletes from others. The validity of the resting heart as a measure of the effect of athletic training was found to be r = .76 by Henry. Because of this high correlation, that validity was improved very little by adding items from the blood pressures. He did, however, propose a two-item test combining heart rate with systolic pulse wave amplitude which proved to have a validity of .82 (15:29-40).

Michael (23:58) also found in 1960 that the mean pressure, pulse pressure, and other combinations of pressure measurements did not change during the time the pulse rate indicated conditioning was changing over a six-week training period.

Reliability of the Heartometer

The reliability of the Heartometer when operated by a trained person was calculated by Cureton (5:268) at the University of Illinois. His results are shown in Table II on page 21.

Henry (15:29-40) indicates these figures are much higher than can ordinarily be expected and reports his own computation on the systolic amplitude (r = .74) and the heart rate (r = .67). He indicates the size of these co-efficients are inadequate for measuring a subject's status and estimates that six measurements be averaged to obtain a dependable score (r = .92).

TABLE II

RELIABILITY OF HEARTOMETER MEASUREMENTS

Characteristic	r	N
Area of a Single Cycle by Planimeter Measurement	.864	97
Systolic Pulse Wave Amplitude of a Single Cycle	.909	97
Heart Rate	.996	97
Width of a Single Cycle	.979	97
Fatigue Ratio	.854	97
Dicrotic Notch Amplitude	.823	97
Work to Rest Ratio	.640	97
Obliquity Angle	.788	97
Diastolic Surge	.878	48
Diastolic Time	.826	48
Diastolic Pulse Wave Amplitude	.768	48

CHAPTER III

PROCEDURE

I. PRELIMINARY STEPS

This study was conducted over a six week period during the spring of 1968 at East Valley High School. The subjects used for the study were members of the track team at the school.

The subjects participated in three weeks of early season conditioning prior to the study. The preliminary conditioning included light calisthenics, mild stretching exercises and running which presumedly increased over the three weeks to something slightly less than maximum effort. This preliminary conditioning prepared the subjects for the hard running involved in the initial test and also provided an opportunity to develop pace judgement.

II. GROUPING

Thirty of the subjects who were participating in running events and thought most likely to continue on the track team were selected to participate in the study.

The grouping was accomplished by use of a Drop-off Index. The index rated each individual's endurance by measuring his basic speed at a distance of 220 yards and his ability to maintain that speed over a 660-yard distance. The purpose for grouping was to equate the groups on their potential to improve their performance on the 660-yard run, which is an endurance task.

The formula utilized to determine the index was designed by Hall (13) and is shown as: Drop-off=Distance Ratio

$$\frac{\text{Short Run Distance}}{\text{Long Run Distance}} \text{ X Time Ratio } \frac{\text{Short Run Time}}{\text{Long Run Time}}$$

The basic speed measurement obtained by performance on the 220-yard run was taken from an average of three runs on three consecutive days. The time for the 660-yard run was taken on the fourth day.

The results of the Drop-off Index were numerically ranked from one to thirty. Using the rank order subjects one, six, seven, twelve, thirteen, eighteen, nineteen, twenty-four, twenty-five, and thirty were placed in the control group. Subjects two, five, eight, eleven, fourteen, seventeen, twenty, twenty-three, twenty-six, and twenty-nine were placed in the experimental group. All other subjects were placed in the placebo control group. A sample of this rank order and method of equating the groups appears in Appendix A. The $\underline{t}$ ratios of the Drop-off scores are shown in Table V on page 28.

All the subjects were informed that they were participating in an experiment and by means of a scientific method, some of them were selected to be administered salt tablets daily while others would not. It was explained that the study was being conducted to determine if the salt tablets would have any effect on their performance over the next six weeks of the season as measured by the 660-yard run and the Heartometer recordings.

III. SALT ADMINISTRATION

The experimental and placebo groups were administered tablets daily (school days) from March 27, 1968 to May 10, 1968. The subjects obtained their daily dosage, five tablets, individually from 12:45 to 1:00 P.M. and consumed them at that time.

The sodium phosphate tablets administered the experimental group were composed of the ingredients and weights shown in Table III.

TABLE III

ACTIVE INGREDIENTS PER TABLET OF THE SODIUM PHOSPHATE

Diabasic Sodium Phosphate	177 mg.
Monobasic Sodium Phosphate	165 mg.
Sodium Chloride	125 mg.

The subjects of the placebo group were administered capsules of milk sugar. The examiner was unable to obtain a placebo tablet that duplicated the appearance of the sodium phosphate tablets so a capsule was used and the subjects were informed that two different kinds of salt were being used in the study.

The subjects were instructed to swallow the tablets rather than let them dissolve in their mouth. The tablets were administered by a water fountain which made it possible for the subjects to swallow the tablets immediately.

IV. CARDIOVASCULAR TEST

The Cameron Heartometer was used to measure the cardiovascular condition of each group in an attempt to more thoroughly determine group differences. The Heartometer recordings were made at the end of the six weeks' study.

The procedure for standardizing the recordings as described by the Cameron Heartometer Corporation (3:13) and Cureton (5) were followed as nearly as possible with the exception of testing three hours away from any previous meal. The Heartographs were recorded from 8:30 A.M. to 10:30 A.M.

All subjects were graphed on a practice trial previous to actual testing to acquaint them with the procedure and allow them to be more at ease during the actual test.

Prior to being tested, each subject was instructed to relax, breath normally, lean against the back of the chair, keep both feet flat on the floor, remain still and look straight ahead.

Table IV shows the dates the study began and dates of testing.

TABLE IV

TESTING DATES

First 660-yard run	March 26, 1968
Administration of tablets began	March 27, 1968
Second 660-run	April 10, 1968
Third 660-run	April 24, 1968
Fourth 660-run and Heartograph	May 8, 1968

V. 660-YARD RUN

The 660-yard run was conducted on the one-fourth mile grass track at East Valley High School.

A warm-up was used by the subjects prior to each 660-yard run which consisted of light running and stretching exercises.

The subjects then arranged themselves in groups of five according to their relative speed for the timing of the run.

Timing of the subjects was done by two team managers, an assistant coach and the examiner. The starting was provided by another assistant with the use of a starting gun.

VI. TRAINING

Training sessions were conducted daily beginning at 3:45 P.M. for approximately 1 to 1 1/2 hours.

The training methods varied according to the type of running event in which each subject was participating.

CHAPTER IV

ANALYSIS OF DATA

I. ANALYSIS OF DROP-OFF INDEX

The Drop-off Index scores were treated statistically to determine the similarity of each group's endurance to each of the other groups. The *t* scores representing the comparison between each of the groups are shown in Table V.

TABLE V

THE *t* RATIOS OF THE THREE GROUPS ON THE DROP-OFF INDEX

Control (A) vs. Experimental (B)	Experimental (B) vs. Placebo (C)	Control (A) vs. Placebo (C)
.2380	.4090	.1739

When group A was compared with group B, a *t* of .2380 was obtained.

When group B was compared with group C, a *t* of .4090 was obtained.

When group A was compared with group C, a *t* of .1739 was obtained.

II. ANALYSIS OF THE RUNNING TIMES

Hypothesis

The hypothesis tested was: Sodium phosphate improves the performances of track athletes on the 660-yard run, by a margin statistically significant at the .10 level of confidence, over other groups not using the sodium phosphate.

Because the hypothesis is concerned only with improvement, the .10 level of confidence is determined by a one-tailed test.

Results

The mean scores were calculated for each of the three groups on the four tests of the 660-yard run. Table VI indicates experimental group B had the lowest mean of the three groups on each of the tests. See page 31.

On Test 1, group B was superior with a mean of 105.50 seconds compared to 107.86 seconds for the control group A and 108.44 seconds for the placebo control group C.

The means of Test 2 show that group B maintained a superior average with a mean of 102.50 seconds compared to 105.10 seconds for Group A and 106.09 seconds for group C.

The means of Test 3 indicate group B remained superior with a mean of 102.90 seconds. However, group C became superior to group A with respective means of 104.37 seconds and 108.78 seconds. This relative rank for the groups was the same for Test 4. The means were 96.15 seconds for group B, 98.41 for group C, and 100.94 for group A.

The Fisher _t_ was used to determine any significant difference between any two groups on any of the four tests. Table VII indicates a significant difference at the .10 level of confidence between groups B and A during Test 3 and Test 4. The other ratios indicate no significant difference at the .10 level of confidence.

When group A was compared with group B, a _t_ of .8082 was obtained for the Test 1, a _t_ of .82018 for Test 2, a _t_ of 1.8261 for Test 3 and a _t_ of 1.8566 for Test 4.

When group B was compared with group C, a _t_ of .8855 was obtained for Test 1, a _t_ of 1.2552 for Test 2, a _t_ of .5122 for Test 3, and a _t_ of 1.0660 for Test 4.

When group A was compared with group C, a _t_ of .2339 was obtained for Test 1, a _t_ of .2661 for Test 2, a _t_ of 1.2820 for Test 3, and a _t_ of .9620 for Test 4.

A comparison of _t_ ratios between the control and experimental groups on the initial and last tests show a difference of 1.0484. This compares to a difference of .7281 for the control and placebo groups.

III. ANALYSIS OF HEARTOGRAPH

The Fisher _t_ was used to determine whether a significant difference existed between any two groups of eight items taken from recordings of the Heartometer. Table VIII on page 32

TABLE VI

COMPARISONS OF MEANS BETWEEN THE THREE GROUPS ON THE FOUR TESTS OF THE 660-YARD RUN

Groups	Test 1	Test 2	Test 3	Test 4
A-Control	107.86	105.10	108.78	100.94
B-Experimental	105.50	102.50	102.90	96.15
C-Placebo	108.44	106.09	104.37	98.41

TABLE VII

THE *t* RATIOS OF THE THREE GROUPS ON THE FOUR TESTS OF THE 660-YARD RUN

Groups and Degrees of Freedom	Test 1	Test 2	Test 3	Test 4
A vs. B - 15	.8082	.8201	1.8261	1.8566
B vs. C - 16	.8855	1.2552	.5122	1.0660
A vs. C - 17	.2339	.2661	1.2820	.9620

indicates no significant difference between any two groups on those items.

TABLE VIII

THE *t* RATIOS OF THE THREE GROUPS ON EIGHT ITEMS OF THE HEARTOMETER PULSE WAVE TEST

Item	A vs. B	B vs. C	A vs. C
Systolic Pulse Wave Amplitude	.6172	.1197	.9375
Dicrotic Notch Amplitude	.8000	.3846	.3125
Diastolic Pulse Wave Amplitude	.8000	.4347	.0838
Diastolic Surge	.4000	.0416	.2973
Rest to Work Ratio	.0000	.6400	.7079
Fatigue Ratio	.4035	.8269	.2857
Ejection Angle	.1557	1.0981	.9743
Area Under the Curve	.6756	.0156	.5882

CHAPTER V

SUMMARY

Thirty members of the Moxee East Valley High School Track Team who participated in running events were subjects of this study conducted during the spring of 1968. The subjects participated in three weeks of early season conditioning prior to the six-weeks study. Subsequent to the preliminary training the subjects were placed in equated groups by means of a drop-off index.

The experimental group B was administered sodium phosphate tablets daily for six weeks. The placebo control group C was also administered tablets they believed to be sodium phosphate; however, they were composed of milk sugar. The control group A went without tablets or suggestive devices.

At two-week intervals the groups were tested on a run of 660 yards and the data was treated to determine significant differences between the groups at the .10 level of confidence. Heartographs of each group were recorded at the end of the study. Eight characteristics of the Heartometer Pulse Wave were measured and *t* ratios between the groups calculated to determine group differences.

I. RESULTS

1. The administration of sodium phosphate as regulated in this study did significantly increase the performance of the experimental group on the 660-yard run at the .10 level of confidence over a time period of four and six weeks when compared to the control group receiving no suggestive devices.
2. There was no significant difference at the .10 level of confidence between the experimental group and the placebo control group at the 660-yard run.
3. There was no significant difference at the .10 level of confidence between the placebo control group and the control group at the 660-yard run.
4. There was no significant difference at the .10 level of confidence between any of the groups on the eight characteristics of the Heartometer Pulse Wave.
5. The level of significant difference between the experimental group and the control group showed more gain than the difference between the control and placebo groups.

II. CONCLUSIONS

The results of this study indicate that the administration of sodium phosphate, as regulated in this experiment, does not significantly increase the performance of track athletes at the .10 level of confidence on the 660-yard run. However, the results do show a beneficial influence. It was also concluded that there was no significant difference in the cardiovascular condition as measured by the Cameron Heartometer due to the use of sodium phosphate during training.

III. RECOMMENDATIONS

Since most research studying the effect of phosphates on working capacity have shown beneficial results, the writer recommends that further study be conducted in this area for athletics.

It is also recommended that variations in dosage be studied since this experiment dealt with only one dosage.

The writer recommends research be conducted with varying time lengths for the study and the time between the administration of the sodium phosphate and the daily training session.

Lastly the author recommends the study of phosphate usage at the commencement of training programs and investigation of use by highly motivated athletes.

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BIBLIOGRAPHY

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APPENDIX

APPENDIX A

RANK ORDER OF SUBJECTS

Rank Number	Drop-Off Index
1	1.247
2	1.258
3	1.295
4	1.315
5	1.318
6	1.323
7	1.331
8	1.333
9	1.338
10	1.339
11	1.340
12	1.342
13	1.346
14	1.347
15	1.348
16	1.351
17	1.352
18	1.355
19	1.359
20	1.364
21	1.367
22	1.373
23	1.379
24	1.379
25	1.388
26	1.394
27	1.407
28	1.414
29	1.417
30	1.423

APPENDIX B

METHOD USED FOR EQUATING GROUPS

Group A	Group B	Group C
1	2	3
6	5	4
7	8	9
12	11	10
13	14	15
18	17	16
19	20	21
24	23	22
25	26	27
30	29	28