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THE EFFECTS OF WHEAT GERM OIL ON THE PRECORDIAL
T-WAVE OF CROSS-COUNTRY RUNNERS

A Thesis
Presented to
the Faculty of the Graduate School
Appalachian State University

In Partial Fulfillment
of the Requirements for the Degree
Master of Arts in Health
and Physical Education

by
Donald E. Kennedy
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Approved by

Jay T. Kearney
Chairman, Thesis Committee

Elmer J. Jones
Committee Member

Michael Carter
Committee Member

Lawrence E. Horine
Chairman, Department of Health
and Physical Education

Eratis Williams
Dean of Graduate School

ABSTRACT

Title: The Effects Of Wheat Germ Oil On The Pre-
cordial T-Wave Of Cross-Country Runners

Author: Donald E. Kennedy

Thesis Directed By: Dr. Jay T. Kearney
Assistant Professor of Health and Physical
Education

Institution: Appalachian State University

Abstract: The purpose of this study was to investi-
gate the effects of a high intensity training program with a dietary sup-
plement on the cardiovascular efficiency of cross-country runners. The
cardiovascular index utilized was precordial T-wave amplitude. Eight mem-
bers of the Appalachian State University cross-country team served as sub-
jects and were divided into two equal groups. One group ingested a dietary
supplement, wheat germ oil, and the other group consumed a non-nutritive
placebo. The subjects electrocardiograms were recorded prior to formal
training (T_1), subsequent to five weeks of training (T_2), and following ten
weeks of training (T_3). The training program employed consisted of a com-
bination of continuous running and interval training.

A 2 x 3 factorial design with repeated measures on the second
factor was the statistical technique utilized. The analysis of data re-
sulted in the following conclusions: The addition of the wheat germ oil
dietary supplement to a high intensity training program produced no signifi-
cant changes in T-wave amplitude; A significant gain in T-wave amplitude due
to training was found only in the immediate post-exercise recording subsequent
to 5 and 10 weeks of training with no significant gains being indicated in

the resting T-wave, five minute post-exercise, and ten minute post-exercise condition; No significant interaction between the training and dietary supplement was evidenced.

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CHAPTER I

INTRODUCTION AND STATEMENT OF THE PROBLEM

A. Introduction

The adequacy of the heart and circulatory system are of fundamental importance to physiological well-being. The cardiovascular system serves as the body's major means of transportation and thus provides the elements necessary for muscular movement and life itself. Activity increases the demands placed on the cardiovascular system and requires an accelerated rate of blood and lymph flow to the active muscles. To accommodate the needs of the active musculature engaged in exercise, numerous acute alterations occur within the cardiovascular system: (1) heart rate increases; (2) stroke volume increases; (3) cardiac output increases; (4) systolic blood pressure increases; and (5) peripheral resistance decreases. There are also chronic consequences of regular rhythmic exercise: (1) hypertrophy of the myocardium; (2) increased collateral vascularization; (3) probable improvement of enzymatic efficiency within the musculature; and (4) myocardial endurance improvement which is proportionally larger than the hypertrophic reactions.^{1,2}

¹Roscoe C. Brown, Jr. and Gerald S. Kenyon (eds.), Classical Studies on Physical Activity (Englewood Cliffs, New Jersey: Prentice Hall, Inc., 1965), pp. 94-97.

²H. Harrison Clarke, Application of Measurement to Health and Physical Education (Englewood Cliffs, New Jersey: Prentice Hall, Inc., 1968), pp. 194-201.

Experimenters generally agree there are numerous factors affecting the elements involved in cardiovascular type tests. Affecting most indices of cardiovascular efficiency are habitual levels of exercise, sex, age, diet, climate, seasons, altitude, and body posture. As a result of this complexity a variety of methods have evolved for assessing the status of the cardiovascular system.³

One of the procedures which has become an accepted means of evaluating the cardiovascular system is an electrocardiogram.⁴ The nature of the test is such that it is free of motivational or conscious effects and may be administered with minimal risks.⁵ Specifically, the recording pattern of an electrocardiogram is a diagram of the electrical flow associated with each heart beat. Researchers have learned that certain patterns of ion flow are associated with each beat of the heart and that the current flow may be monitored on the body surface.⁶ The pattern recorded with surface electrodes usually consists of a P-wave, "QRS complex," and T-wave. The P-wave corresponds with atrial activation, the "QRS complex" represents

³Ibid.

⁴Physicians Handbook for Evaluation of Cardiovascular and Physical Fitness (Nashville, Tennessee: Prepared by Tennessee Heart Association Physical Exercise Committee, 1972), pp. 5-29.

⁵Robert M. Poiletman and Harry A. Miller, "The Influence of Wheat Germ Oil on the Electrocardiographic T-Waves of the Highly Trained Athlete," Journal of Sports Medicine and Physical Fitness, 8:26-33, March, 1968.

⁶Arthur C. Guyton, Function of the Human Body (Philadelphia: W. B. Saunders Co., 1965), pp. 124-25.

ventricular excitation, and the T-wave is representative of repolarization of the ventricles.⁷

Cardiovascular adaptations to training have been shown to produce changes in the electrical activity of the heart. Usual recorded patterns on the electrocardiogram indicate a slower cardiac rate and higher voltages in the "QRS complex" and T-waves.⁸ Research has shown that the most effective means of bringing about these marked changes is through a strenuous program of progressive dosages of continuous rhythmic activity.⁹

Characteristics of the precordial T-wave of the electrocardiogram have been studied extensively by Cureton¹⁰ and Carlile and Carlile¹¹ showing it is of considerable importance in predicting levels of physical endurance. The correct dosage of physical training usually increases T-wave amplitude, a mild program elicits no changes, and too strenuous a program produces a depressed T-wave. Results of the experiments suggest that the

⁷Robert M. Berne and Matthew N. Levy, Cardiovascular Physiology (St. Louis: C. V. Mosby Company, 1967), p. 26.

⁸George L. Beckner and Travis Winsor, "Cardiovascular Adaptations to Prolonged Physical Effort," Circulation, 9:835-46, June, 1954.

⁹T. K. Cureton, "Effects of Longitudinal Physical Training on the Amplitude of the Highest Precordial T-Wave of the ECG," Medicina Sportiva, 12:259-81, 1958.

¹⁰Ibid.

¹¹Forbes Carlile and Ursula Carlile, "T-Wave Changes in the Electrocardiogram Associated with Prolonged Periods of Strenuous Exercise in Sportsmen with Special Reference to Application in Training Swimmers," Australian Journal of Physical Education, 17:10-20, 1959.

precordial T-wave is a reliable indicator of the training status of the myocardium.¹²

Other studies¹³ have indicated a dietary supplement wheat germ oil may also be beneficial to the development of the cardiovascular system. According to Cureton, a lack of good cardiovascular and muscular development may be associated with poor nutrition.¹⁴ The ingredients of wheat germ oil are believed to affect the condition of the veins and arteries and improve the functioning of the heart.¹⁵ The improved functioning of the heart and vascular system comes about through utilization and assimilation of wheat germ oil which further facilitates overall body efficiency.¹⁶

Theoretically, the attainment of improved cardiovascular development through consumption of wheat germ oil should be indicated by significant increases in the precordial T-wave amplitude. These changes should be supplemental to those produced by strenuous physical training.¹⁷

¹²T. K. Cureton, "What About Wheat Germ?" Scholastic Coach, 29:24, 26, 48, 1959.

¹³Ibid.

¹⁴T. K. Cureton, "Wheat Germ Oil the Wonder Fuel," Scholastic Coach, 24:36-7, 1955.

¹⁵T. K. Cureton, "What About Wheat Germ?" loc. cit.

¹⁶T. K. Cureton, "Wheat Germ Oil the Wonder Fuel," loc. cit.

¹⁷William A. Smiley, "Variations on a Bicycle Ergometer Test with Altitude, Training, and a Dietary Supplement" (unpublished Master's thesis, University of Illinois, 1951), p. 90.

B. The Problem

1. Statement of the Problem

A sound program of progressive physical training brings about desirable changes in the function of the heart and circulatory system.¹⁸ It has also been hypothesized that dietary supplements may aid in improvement of the cardiovascular system.¹⁹ This study investigated the combined effects of a program of regular physical exercise and a dietary supplement of wheat germ oil. In consideration of its qualities of reliability and objectivity, the criterion of cardiovascular improvement used was the amplitude of the T-wave. Specifically, the effect on the amplitude of the precordial T-wave of high intensity training while consuming a standard or wheat germ oil supplemented diet has been investigated.

2. Scope of the Study

Eight members of the Appalachian State University Cross-Country team were used as subjects. The subjects were divided into equated groups based on the initial recording of the amplitude of the precordial T-wave of the electrocardiogram. One group of four men took wheat germ oil (10 capsules per day, six minims each) as a dietary supplement. The four men in the other group received a non-nutritive placebo (10 capsules per day). The capsules were ingested prior to each day's training session. The wheat germ oil and placebo were administered on a double blind basis.

¹⁸John A. Friedrich, "Exercise in the Maintenance of Cardiovascular Health - An Overview" (Paper read at the Symposium: Prescribing Exercise for the Maintenance of Cardiovascular Health, 1972, Charlotte, North Carolina), pp. 21-4.

¹⁹T. K. Cureton, "What About Wheat Germ?" loc. cit.

The runners were tested at the beginning of formal training (T_1), at the conclusion of five weeks of training (T_2), and following ten weeks of training (T_3). All testing was done in the University Medical Center. The electrocardiographic tests were recorded in the precordial position (lead V_4) under the following conditions: (1) reclining rest; (2) 30 seconds after a bench-stepping exercise; (3) five minutes following the bench-stepping exercise; (4) ten minutes following the bench-stepping exercise. The bench-stepping exercise was performed at a rate of 30 steps per minute for five minutes on a 17-inch bench.

Standard descriptive statistics consisting of means and standard deviations of T-wave amplitude are presented. The inferential statistical analysis utilized was a 2 x 3 factorial design with repeated measures on the second factor.²⁰

3. Definition of Terms

a. T-wave. The T-wave is the second major wave of the electrocardiogram and is relatively prolonged but of considerably less voltage than that of the R-wave. Deflection takes place immediately following the rapid depolarization of the ventricle muscle. The restoration of the polarized state of the ventricle muscle through a slow ion movement is known as the repolarization process. The ventricular muscle repolarization process initiates an electrical potential that is recorded as the T-wave on the electrocardiogram.²¹

²⁰C. Mitchell Dayton, The Design of Educational Experiments (New York: McGraw-Hill Book Co., 1970), pp. 256-68.

²¹Arthur C. Guyton, Textbook of Medical Physiology (Philadelphia: W. B. Saunders Co., 1968), pp. 196-97.

b. Precordial Lead (Chest Lead). The precordial electrocardiogram is recorded by various electrode placements over the heart, on the anterior portion of the chest. The chest electrode is connected to the electrocardiogram's positive terminal with the negative electrode (the indifferent electrode) being made through connections of electrical resistances of the right arm, left arm, right leg, and left leg. There are six different standard precordial leads with V_4 the one being used in this study. For the V_4 lead the positive electrode is placed on the midclavicular line within the fifth interspace.²²

4. Limitations

There are several limiting factors that may have affected the results of this study. Some of the limitations directly related to the investigation were:

a. Control of human subjects was extremely difficult and could only be carried out to a limited extent.

(1) Variations in diet from non-nutritive snacks to over indulgence of necessary foods may have been reflected in the study.

(2) Extracurricular exercise beyond that of the daily cross-country practice sessions may have had an effect on the study.

(3) Lack of sufficient rest due to social activities or late hours studying may have influenced the results.

²²Ibid., p. 203.

(4) There was considerable variance as to the relative condition of each subject at the beginning of the study.

b. The occurrence of injuries was a limiting factor.

(1) This resulted in breaks in the intense training schedule.

(2) As a result of injuries subjects had to be dropped from the study.

c. The placebo provided by the company supplying the supplements was not as well disguised in appearance as it could have been. The wheat germ oil capsule was darker in coloration as compared to the placebo.

CHAPTER II

REVIEW OF RELATED LITERATURE

This chapter presents a review of the research relevant to this investigation. The chapter has been divided into two specific sections. Section A reviews the literature related to the effects of training on the T-wave. The second section discusses the effects of wheat germ oil on the T-wave of the electrocardiogram.

A. Effect of Training on the T-Wave

In predicting levels of physical endurance the precordial T-wave has become increasingly important. This is indicated through evidence of relatively parallel behavior between precordial T-waves and gross oxygen intake.¹ Further credence has been established by the unusually large T-waves of highly trained athletes.² The increased T-wave amplitude is generally a result of a progressively strenuous physical training program.³

In a study of the electrocardiograms of athletes hearts, Cooper, O'Sullivan, and Hughes reported that the most notable feature was marked deviations in overall amplitude. Factors such as a shorter systolic

¹T. K. Cureton, "Effects of Longitudinal Physical Training on the Amplitude of the Highest Precordial T-Wave of the ECG," Medicina Sportiva, 12:259-81, 1958.

²George L. Beckner and Travis Winsor, "Cardiovascular Adaptations to Prolonged Physical Effort," Circulation, 9:835-46, June, 1954.

³Cureton, loc. cit.

period, rise in temperature of the blood, diastolic pause reduced to a great extent, and variation in the chemistry of the blood are all thought to play a part in the electrocardiographic changes during exertion. Another important consideration is the position of the heart within the chest cavity, particularly that of post exercise displacement as a result of greater diaphragmatic excursion. With these factors in mind the researchers reviewed the electrocardiograms of university and high school athletes. The investigation revealed that the T-waves were extremely high in many cases and were even greater in recordings taken immediately after exercise.⁴

Kraus and Nicolai compared resting electrocardiograms of untrained subjects and trained athletes. The investigators reported that the ECGs were essentially the same with exception to the T-wave of the trained athletes which was slightly higher.⁵

An investigation of electrocardiographic changes resulting from a complete season of physical training was made by Tuttle and Korn. Forty-eight athletes, all of whom participated regularly in varsity level competition, were tested. There were 22 track men, 9 swimmers, 7 gymnasts, 6 basketball players, and 4 wrestlers. Electrocardiographic recordings were made at the beginning of each athlete's training season and again after

⁴E. L. Cooper, J. O'Sullivan, and E. Hughes, "Athletics and the Heart: An Electrocardiographic and Radiological Study of the Response of the Healthy and Diseased Heart to Exercise," Medical Journal of Australia, 1:569-79, April, 1937.

⁵F. Kraus and G. Nicolai, Das Elektrokardiogramm des Gesunder Und Kranken Menschen, Leipzig, 1910, cited by W. W. Tuttle and H. M. Korn, "Electrocardiographic Observations on Athletes Before and After a Season of Physical Training," American Heart Journal, 21:104-07, January-June, 1941.

active competition and strenuous training. Only four or 8.3 percent exhibited measurable changes in the electrocardiogram.⁶

The effects of exercise on the electrocardiogram have also been investigated by Wolf. The researcher used two groups of subjects. One group was composed of 102 untrained individuals while the other included 12 members of a university cross-country and track team. The criteria used to reveal the cardiovascular condition of each subject were an "all-out" treadmill run and electrocardiographic recordings being made during the recovery period. The untrained group was subsequently divided into three groups of poor, average, and good condition. The group of trained athletes remained as a single unit. Analysis of the differences in ECG recordings among the various subgroups within the untrained group was completed by using a small sample "t" test. ECG variations between the good (N=34) and poor (N=34) subgroups indicated that it was possible to differentiate between the levels of condition of these subgroups. Variations were not great enough to differentiate between the good and average or average and poor condition subgroups. The researcher did not report any statistically significant differences in ECGs of the trained subjects.⁷

Beckner and Winsor studied the cardiovascular systems of 165 male marathon runners and 40 non-runners. The marathon runners had been competing for more than five years while the non-runners were employed

⁶W. W. Tuttle and H. M. Korns, "Electrocardiographic Observations on Athletes Before and After a Season of Physical Training," American Heart Journal, 21:104-07, January-June, 1941.

⁷J. Grove Wolf, "Effects of Posture and Muscular Exercise on the Electrocardiogram," Research Quarterly, 24:475-90, December, 1954.

in relatively sedentary occupations. ECG recordings on the runners were made prior to and after running 26, 18 and 10 miles. The recordings taken at rest were compared to those of the non-runners. The investigators found that the runners had a slower resting cardiac rate and the voltages of the QRS complex, T and U-waves were considerably higher. In specific reference to the precordial recordings the T-waves of the non-runners averaged 7.7 mm. in comparison to a 9.2 mm. average of the runners.⁸

In order to assess the value of the precordial T-wave as a criterion measure for changes in physical condition, Cureton analyzed the influence of different intensities of training on overall T-wave amplitude. Mild training produced virtually no changes whereas a progressive program of gradually increasing intensity resulted in significant increases in amplitude. The researcher also reported that overwork resulted in a depression of the T-wave which persisted until substantial rest was acquired.⁹

Using cyclists and swimmers, Carlile and Carlile studied the acute and chronic effects of prolonged strenuous exercise on the T-wave of the electrocardiogram. Recordings were made on the subjects, 100 swimmers and 6 world class racers, throughout their training periods. The subjects did not exercise on the test days. During the experimental period some of the subjects were also involved in special experiments such as undergoing extreme doses of exercise as in the case of the cyclists, a six

⁸Beckner and Winsor, loc. cit.

⁹Cureton, loc. cit.

day race. The extra experiments were done in order to attain as much information as possible on the effects of the different intensities of training on the T-wave. The results indicated that relatively easy training brought about essentially unchanged electrocardiograms, whereas strenuous training resulted in changes in a majority of the subjects ECGs. The changes were directly related to the correct amount of training. Results of some of the special experiments showed that strenuous exercise for an extended period caused the T-wave to stay flattened for a prolonged length of time. Strenuous exercise for shorter periods within the conditioning level of the athlete affected only the heart rate. The investigators in reviewing the different ECG leads used, further revealed that the precordial V_4 lead was generally more effective in indicating the results of the different levels of stress during the training program. In an overall view of the study the investigators concluded that the electrocardiograph was an objective means to detect physical strain and to some extent measure the degree of strain.¹⁰

Plas reported on the electrocardiograms of trained athletes exposed to work and prolonged effort. The researcher found that the amplitude of the precordial T-wave taken during and after prolonged effort was three to four times as great as the average resting T-wave. The researcher further stated the maximum height of the T-wave could occur at the peak of conditioning and would diminish proportionally as the level of physical

¹⁰Forbes Carlile and Ursula Carlile, "T-Wave Changes in the Electrocardiogram Associated with Prolonged Periods of Strenuous Exercise in Sportsmen with Special Reference to Application in Training Swimmers," Australian Journal of Physical Education, 17:10-20, 1959.

efficiency was lowered.¹¹ These conclusions are in accordance with findings in previously reported reviews.^{12,13,14}

The electrocardiograms of 21 high level marathon runners were studied by Smith, Cullen, and Thorburn. All of the runners were competing in the 1962 Commonwealth games. Electrocardiographic recordings on each competitor were taken before and as soon as possible after the completion of the race. It was possible to get only 18 post race recordings. The most significant characteristics of the pre-race ECGs were a slow heart rate, tall U and T-waves, and larger than normal voltage of the QRS complex. Post race recordings revealed increased amplitude of the P-wave, QRS complex and T-wave. The mean of the tallest T-wave amplitudes recorded with the precordial leads in the pre-race test was 9.9 mm. The post race recording increased to a mean of 11.4 mm. Occurrence of the tallest T-waves was equally distributed among the V_3 , V_4 , and V_5 leads. The T-waves of eight runners were greater after the race, four were smaller, and six were essentially unchanged.¹⁵

¹¹Fernand R. Plas, "Electrocardiographic Changes during Work and Prolonged Effort," Journal of Sports Medicine and Physical Fitness, 3:133-36, 1963.

¹²Cooper, O'Sullivan, and Hughes, loc. cit.

¹³Beckner and Winsor, loc. cit.

¹⁴Carlile and Carlile, loc. cit.

¹⁵W. G. Smith, K. J. Cullen, and I. O. Thorburn, "Electrocardiograms of Marathon Runners in 1962 Commonwealth Games," British Heart Journal, 26:469-76, 1964.

Noon used T-wave amplitude as one of many tests in investigating the effects of two different training regimens on young runners. Two groups of subjects were used, one undergoing a speed training program (sprints of 50, 110, 220, 330, or 440 yards at faster than race pace) while the other was on an overdistance program (long steady runs from five to 15 miles and repeated 880, 1320, mile, and two mile runs). Resting and post-exercise recordings were taken at the beginning and end of a twelve week training period. In evaluating each subject's electrocardiogram the author took special note of T-wave changes in specific regard to the V_4 lead. In the final resting ECGs, as compared to the initial recordings within each group, the overdistance group had slightly depressed T-waves while the T-waves of the speed group increased significantly. The initial exercise ECGs were taken and compared to the final exercise recordings within each group. In the final exercise the T-wave recordings of the overdistance group were slightly depressed or indicated no change. The speed training group, however, increased from 6.9 mm. to 8.9 mm. which was statistically significant. As indicated by the significant differences in the speed training group's ECGs, the most marked T-wave changes were produced by the intense training program.¹⁶ The author has exhibited further evidence of the use of the T-wave in specific references to the V_4 lead, and how it is affected by an intense training program.

¹⁶Tom Noon, "Effect of Speed and Overdistance Training on Young Runners," Track Technique, 21:646-51, 1965.

B. Effect of Wheat Germ Oil on the T-Wave

According to Cureton, the practical aspects of performance are the main points of interest in a physical fitness program geared toward attaining an increased level of conditioning. The physiological or psychological impetus to reach the end result are of lesser importance. Nutritionists are the ones interested in biological evaluations of supplementary vitamins used to improve human performance. Those in the medical and public health areas are interested in knowledge of long-range effects of supplementary vitamins. Evidence from sources not closely related to medical science are, however, not acceptable by many of these professionals.¹⁷

After 20 years of experiments at the University of Illinois, Cureton seems to be convinced that a dietary supplement of wheat germ oil has measureable and beneficial effects on human performance and the efficiency of the cardiovascular system. The investigator stated that the facilitatory effect can possibly be attributed to the fact that the diet of modern man is lacking fresh polyunsaturated acids. The research on wheat germ oil does not specifically deal with heart disease, but the poor cardiovascular condition associated with inactivity and poor diet may foster the incidence of similar pathological conditions. Additionally, Cureton also reported that the experiments completed indicated the subjects had greater capabilities of bearing stress when wheat germ oil was included in their diet.¹⁸

¹⁷T. K. Cureton, The Physiological Effects of Wheat Germ Oil on Humans in Exercise (Springfield, Illinois: Charles C. Thomas, 1972), pp. xv-xx.

¹⁸Ibid.

The physiological tests employed by Cureton have been used for many years at the University of Illinois Physical Fitness Research Laboratory. Many of the tests utilized are standard tests of muscular endurance and cardiovascular efficiency known by those in the medical and nutritional fields. Others are not as well known and, when employed, have included explanations of reliability and validity. The majority of the research conducted utilized longitudinal assessment of changes in relation to the many different physiological measures. Studies of the effects of dietary supplements were essentially additions to the type of research projects that had been previously conducted.¹⁹

In further discussion, Cureton has stated that a minimum of six weeks of consumption is needed for wheat germ oil to have time to produce an evaluable effect on cardiovascular fitness. The dosage usually administered in the Illinois studies was 10 six minim capsules per day. The researcher also suggested that more reliable results would be obtained if the subjects had undergone a pre-experimental training period to reach a physical fitness plateau before consumption of the dietary supplement was begun.

One of the many studies on wheat germ oil conducted at the University of Illinois was carried out by Forr. In order to determine the effects of the dietary supplement on physical fitness Forr used the T-wave of the electrocardiogram as one of numerous tests. The subjects were a group of college age males (17-26 years) who participated in the university

¹⁹Ibid., pp. 5-20.

physical education program. After administering three tests—the heart-ograph, Schneider Index, and five minute step test—the subjects were divided into three matched groups. Group I (N=8) was a fraternity group taking regular physical education activity classes, Group II (N=9) was a physical education swimming class, and Group III (N=9) was a control or no exercise group. Within the fraternity and swimming groups, the subjects were divided into matched groups taking wheat germ oil (A), groups taking synthetic vitamin E (B), and a group taking corn oil (C). The experiment lasted twelve weeks with the subjects doing the required activities in their respective classes. The results of the ECG tests indicated significant changes in T-wave favoring the wheat germ oil group (A), when comparing it to the synthetic vitamin E group (B). The results were found to be significant to the .01 level. Other comparisons were not reported to be significant.²⁰

Maley used the T-wave as a part of a study of the effects of wheat germ oil on cardiovascular tests administered to adult men. Eighteen subjects were tested and divided into two matched groups on the basis of the following five tests: (1) five-step (Cureton) pulse ratio test; (2) Schneider Index; (3) Cameron Heartograph; (4) Harvard Step Test; and (5) ECG T- and R-waves. All subjects were involved in a physical training program composed of swimming, calisthenics, and various games. Four months after the first test administration the same battery of tests were repeated. During the succeeding six week period one group consumed the

²⁰William A. Forr, "The Effects of Wheat Germ Oil (Vitamin E) on Physical Fitness" (unpublished Master's thesis, University of Illinois, 1950), pp. 66-70.

dietary supplement while the other took a placebo. Analysis of the resulting data indicated no significant changes during the six week period in which the wheat germ oil supplement was consumed and the exercise program continued.²¹

The T-wave was used by Susic in assessing the effects of hard training and wheat germ oil on cardiovascular efficiency. An experimental group (N=6), exercise control group (N=3), and non-exercise control group (N=3) were used. The experimental subjects underwent an endurance training program in addition to taking wheat germ oil. The exercise control group was involved in the endurance training only, while the non-exercise group underwent no training. The pre-training T-wave amplitude (T-1) of the experimental subjects averaged 10.88 mm. and increased to 12.00 mm. after 12 weeks of endurance training (T-2). A wheat germ oil supplement was added during the six additional weeks of training between T-2 and T-3. During this period the mean T-wave amplitude increased to 14.90 mm., which was significant at the .01 level. T-wave changes in the exercise control group and non-exercise control group from T-1 to T-2 and from T-2 to T-3 were statistically non-significant. As a result of the significant findings within the experimental group, the investigator concluded that the addition of wheat germ oil during the last six weeks of the 18 week program produced a

²¹Arthur F. Maley, "The Effects of Training and a Dietary Supplement on the Cardiovascular Fitness of Adult Men" (unpublished Master's thesis, University of Illinois, 1952), p. 36, cited by T. K. Cureton, The Physiological Effects of Wheat Germ Oil on Humans in Exercise (Springfield, Illinois: Charles C. Thomas, 1972), pp. 346-50.

positive influence on the ability to withstand an extended period of hard training.²²

One of the test items Vohaska used in a study on the effects of wheat germ oil on varsity wrestlers was the T-wave of the electrocardiogram. The subjects were college level wrestlers who underwent a complete season of wrestling. Based on the results of a composite six item cardiovascular test the subjects were divided into two matched groups, N=11. The dietary supplement, wheat germ oil, was administered to one group, while the other consumed a placebo of cottonseed oil. The addition of the supplements was made after four weeks of the season and was continued for a period of four weeks. No significant differences were reported between the cottonseed oil group and the wheat germ oil group.²³

In 1953 Cureton and Pohndorf did a follow-up wheat germ oil study based on the previous experiments completed at the University of Illinois. The subjects were middle-aged men engaged in a prescribed physical fitness program. One of the tests administered to indicate any differentiation between the wheat germ oil group and a placebo group was the T-wave of the electrocardiogram. After the initial cardiovascular test the subjects were divided into matched groups of eight subjects. The subjects underwent an

²²Steve Susic, "The Effect of Training and Dietary Supplement on the T-Wave of the ECG at Ground Level and at 10,000 Feet of Simulated Altitude" (unpublished Master's thesis, University of Illinois, 1953), p. 50.

²³William J. Vohaska, "The Effects of Wheat Germ Oil on the Cardiovascular Fitness of Varsity Wrestlers" (unpublished Master's thesis, University of Illinois, 1954), p. 43, cited by T. K. Cureton, The Physiological Effects of Wheat Germ Oil on Humans in Exercise (Springfield, Illinois: Charles C. Thomas, 1972), pp. 351-52.

eight week training program, one group taking the wheat germ oil while the other took a lard placebo. A group of 10 inactive controls were also used and divided into a wheat germ oil and placebo group. The researchers reported significant within group changes in T-wave amplitude in both the wheat germ oil group and the placebo group. The resultant gains in T-wave amplitude reported were thus attributed to the exercise. No significant differences were reported within or between the wheat germ oil inactive control groups.²⁴

The T-wave of the electrocardiogram was one of several tests of cardiovascular fitness Bernauer used to investigate the effects of wheat germ oil on a group of varsity track athletes. Twelve runners were involved in the experiment. On the basis of a 440 yard run time, the subjects were divided into two matched groups with six runners in each. A twelve-week training program was undertaken during which six of the subjects consumed wheat germ oil while the other six took a non-nutritive placebo. At the end of the experimental period no significant differences were found in either the wheat germ oil group or control group.²⁵

In evaluating a United States Navy training program for underwater swimmers, Cureton used the electrocardiographic T-wave as one of many cardio-

²⁴T. K. Cureton and R. H. Pohndorf, "Influence of Wheat Germ Oil as a Dietary Supplement in a Program of Conditioning Exercises with Middle Aged Subjects," Research Quarterly, 26:391-407, December, 1955.

²⁵Edmund M. Bernauer, "The Influence of Wheat Germ Oil as a Dietary Supplement in a Training Program of Varsity Track Athletes at the University of Illinois" (unpublished Master's thesis, University of Illinois, 1958), cited by T. K. Cureton, The Physiological Effects of Wheat Germ Oil on Humans in Exercise (Springfield, Illinois: Charles C. Thomas, 1972), pp. 402-10.

vascular tests. The primary objective of the study was to evaluate physical fitness levels attained with a secondary aim being concerned with the effects of a dietary supplement on physical fitness. Thirty prospective male scuba divers were used as subjects. After an initial battery of physical fitness tests were administered the subjects were divided into three matched groups. Group A (N=10) was fed the dietary supplement octacosanol, which is derived from wheat germ oil, Group B (N=10) took a cottonseed oil placebo, and Group C (N=10) took the wheat germ oil. The training program lasted six weeks and was composed of an intensive physical conditioning program involving swimming, running, scuba diving, land calisthenics, and assorted physical tests. The tests were administered the first and final weeks of the program. The researcher reported no statistically significant within group T-wave changes. Between group comparisons also revealed no statistically significant differences.²⁶

To assess the effect of wheat germ oil on the precordial T-wave Mayhew used a group of middle aged males. The subjects underwent 20 weeks of endurance training consisting of progressive rhythmical exercise. After 10 weeks of training the subjects were divided into three groups based on a one mile run time. A wheat germ oil supplement was administered to one group (N=6), a second group received a placebo (N=6), and the third group served as a control or training only group (N=7). Comparisons among the three groups of subjects were based on precordial T-wave amplitudes recorded at the conclusion of the experimental period with the measures

²⁶T. K. Cureton, "Improvements in Physical Fitness Associated with a Course of U. S. Navy Underwater Trainees, with and without Dietary Supplements," Research Quarterly, 34:440, December, 1963.

recorded after the 10 week training period being used as the covariates. The T-wave amplitude of the wheat germ oil group as compared to the placebo and training only group was significantly greater during the fifth (0.43 mm.) and sixth (0.94 mm.) minute of recovery following strenuous exercise. There were no significant differences in T-wave amplitude between the placebo and training only group. Only in the tenth minute of recovery were the wheat germ oil group and training group significantly greater than the placebo group. There were no significant T-wave differences between the training only and wheat germ oil group.²⁷ The few reported significant findings could be attributed to chance and therefore probably should not be taken as an indication of beneficial effects of wheat germ oil.

Poiletmen and Miller used 24 members of a university cross-country team to evaluate the effects of wheat germ oil on the T-wave of highly trained runners. All subjects had been training for a period of five weeks before the actual testing began. The pre-test training was to establish a high level of conditioning. A division into two groups, 12 subjects each, was made through random selection. For a period of three weeks one group consumed the wheat germ supplement while the other group consumed neither a dietary supplement nor a placebo. The control group was used to assess the effects of continued training. In analyzing the T-waves, each

²⁷Jerry L. Mayhew, "The Effects of Training with and without Wheat Germ Oil on the T-Wave of the Electrocardiogram and Other Selected Fitness Measures of Middle-Aged Men" (unpublished Master's thesis, University of Illinois, 1967), pp. 31-93.

subject was his own control with the mean difference of T-1, initial test before the addition of the dietary supplement, and T-2, after three weeks of continued training with and without the dietary supplement, derived for each group. The mean differences were analyzed by the Fisher "t" test. The investigators found no significant effect of dietary supplementation with wheat germ oil on precordial T-wave amplitudes.²⁸

The T-wave of the electrocardiogram has been extensively utilized in testing cardiovascular fitness and in attempting to ascertain the physiological effects of wheat germ oil. The review of literature has revealed through evidence of variations in amplitude that training produces noticeable changes in the T-wave. Due to a lack of consistency in the statistical treatment of the data, the conclusions contained in the wheat germ oil literature are not in complete accord.

²⁸Robert M. Poiletman and Harry A. Miller, "The Influence of Wheat Germ Oil on the Electrocardiographic T-Waves of the Highly Trained Athlete," Journal of Sports Medicine and Physical Fitness, 8:26-33, March, 1968.

CHAPTER III

PROCEDURE IN RESEARCH

The procedure for investigating the effects of training and the dietary supplement wheat germ oil on the ECG of cross-country runners is presented in this chapter. Included are descriptions of the: (a) subjects; (b) testing procedures; (c) experimental variables; and (d) method used in statistical analysis.

A. Subjects

The subjects used in this study were eight members of the Appalachian State University cross-country team. Their ages ranged from 18.08 to 24.25 years with a mean age of 20.00 years. For complete descriptive data on each subject refer to Appendix A. Each subject was an experienced cross-country runner and represented the institution in intercollegiate competition. Participation was on a voluntary basis with each subject indicating a willingness to participate in the experimental procedure involved in the study.

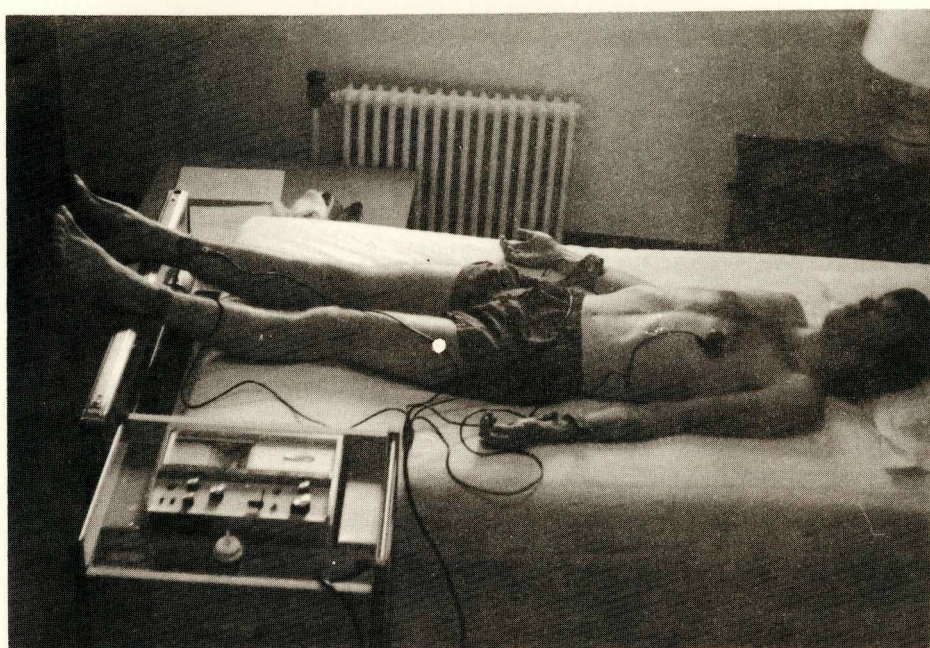
B. ECG Determinations

1. Testing Procedure

The subjects were tested with the electrocardiograph at zero weeks (T_1), after five weeks of training (T_2), and after ten weeks of training (T_3). All testing was done in the University Medical Center between 6:30 a.m. and 9:30 a.m.

Figure 1

Electrode Placement for Burdick EK 4
Dual Speed Electrocardiograph



Each subject was instructed not to eat or drink anything prior to the test and to arrive at the medical center 15 minutes prior to test time. Before being tested the subject rested in the reclining position for 15 minutes. During this period the ECG electrodes were placed on the subject.

Electrode placement was according to instructions in the Operating Manual, EK 4 Dual-Speed Electrocardiograph.¹ The precordial electrode was placed in the V_4 position, the intersection of an imaginary line from the midclavicular position and the fifth intercostal space.² Electrode placement was made consistent by measuring from the specific anatomical reference points on each subject (See Figures 1 and 2 for electrode placement).

Using the Burdick EK 4 dual speed electrocardiograph an initial ECG recording was made after 15 minutes of reclining rest. Following the resting recording each subject performed a bench stepping exercise, 30 steps/min. for five minutes on a 17-inch bench. Immediately following the exercise the subject returned to the supine position and within 30 seconds an immediate post-exercise recording was made. The subject remained in the supine position for ten minutes following the exercise. During this period recordings were made for the five minute post-exercise and 10 minute post-exercise interval (see Appendix B for explicit test protocol).

2. The Test

The selected variable used for this study was the T-wave of the electrocardiogram (see Figure 3 for diagram of ECG). Vernier calipers were

¹Operating Manual EK 4-266 for the Burdick EK 4 Dual-Speed Electrocardiograph (Milton, Wisconsin: The Burdick Corporation), pp. 12-16.

²Ibid.

Figure 2
Precordial V_4 Lead (Chest)
Electrode Position

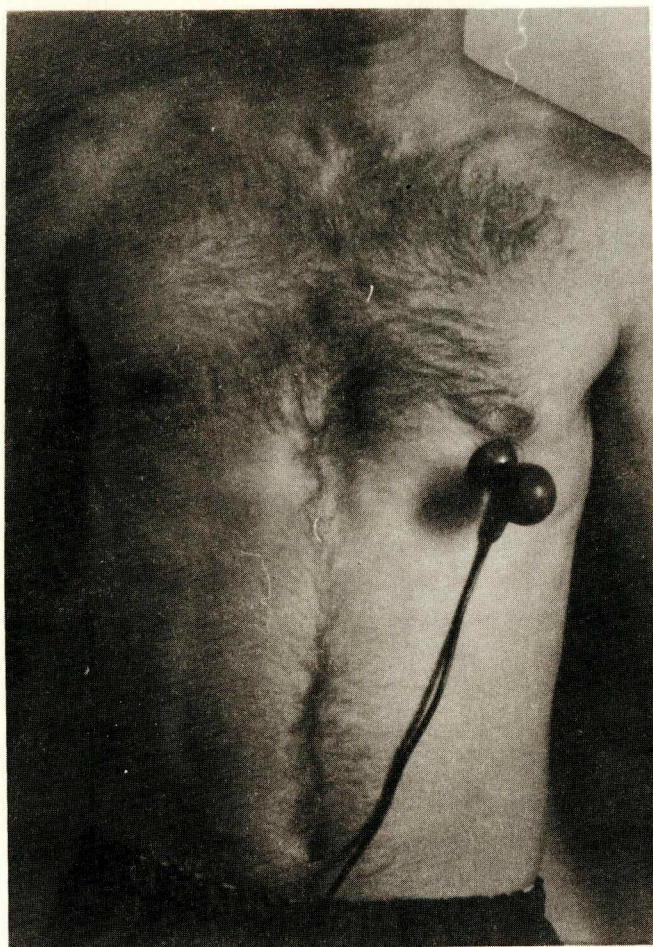
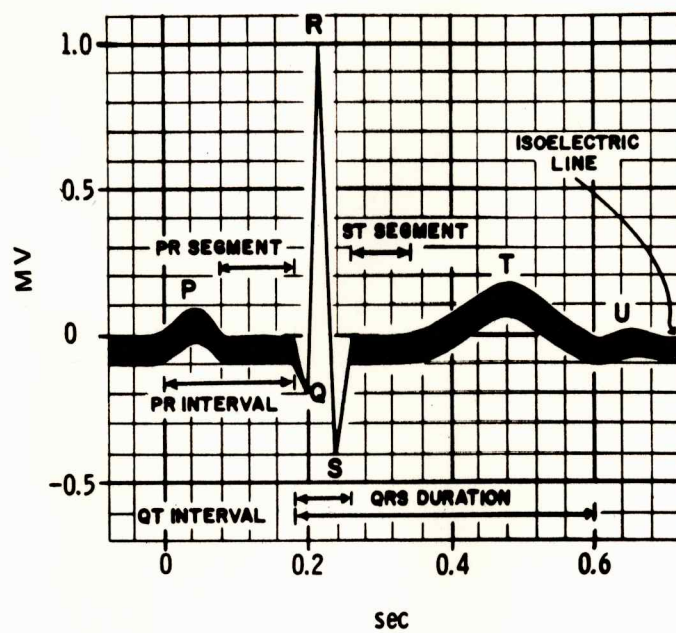


Figure 3
Diagrammatic Example of ECG



used in measuring the amplitude of each deflection. Measurement was made in millimeters from the top of the isoelectric line (straight line produced when no electrical potential is registered)³ to the bottom edge of the vertical deflection. The electrocardiogram was standardized, 1 mv. of potential equals 1 cm. stylus deflection, in accordance to the standard procedure given in the Burdick Operating Manual.⁴ For each recording period ten complexes were measured and averaged to minimize error and give a more representative T-wave amplitude.⁵

3. Test-Retest Reliability

Six subjects who were not members of the Appalachian State University cross-country team were chosen for the determination of test-retest reliability. Each subject was active and exercised daily. The reliability subjects followed the same testing procedure as was used on the cross-country runners. The subjects were tested one week apart at approximately the same time in the morning.

C. Experimental Variables

1. Training

All subjects participated in a strenuous endurance training program with two specific methods being employed. The training methods were

³Michael Bernreiter, Electrocardiography (Philadelphia: Lippincott Co., 1963), p. 11.

⁴Operating Manual EK 4-266, op. cit., p. 81.

⁵Kenneth D. Rose, Proceedings of the 1965 International Telemetering Conference (Pasadena: F. G. McGaucock Associates, 1965), p. 227.

continuous running and interval training. Continuous running training was defined as running at a comfortable and steady pace for extended periods of time without interruption.⁶ The distance covered varied from six to fifteen miles at a pace of 7:00-8:00 mins./mile. The technique of interval training involved repeated efforts of running specific measured distances with alternating low activity recovery periods.⁷ Distances ranged from 220 yards to one mile with recovery periods varying from 45 seconds to five minutes. The length of the rest interval being relative to the pace and distance covered.

In most cases the subjects performed continuous running training on Mondays, Wednesdays, and Fridays interspersed with interval sessions on Tuesdays and Thursdays. Saturdays were usually the days of competitive races over five-mile cross-country courses. Sunday was designated as a rest or very light running day. An example of a two week period of training may be found in Appendix C.

2. Dietary Supplement

In using T-wave amplitude to assess levels of fitness and the value of a dietary supplement it is possible only to compare the ECGs of an individual with previous recordings of the same individual. Following the initial test the subjects were divided into two matched groups on the basis of their reclining rest T-wave amplitude. One group (N=4) received a wheat

⁶Fred Wilt, Run Run Run (Los Altos: Track and Field News, Inc., 1968), p. 174.

⁷J. Kenneth Doherty, Modern Training for Running (Englewood Cliffs, New Jersey: Prentice-Hall, Inc., 1964), p. 87.

germ oil dietary supplement (ten capsules daily, six minims each). The other group (N=4) received a non-nutritive lard placebo (ten capsules daily). All supplements were administered on a double blind basis.

The supplements were distributed to the subjects on all training days immediately prior to the exercise session. On non-training days, or whenever subjects were to miss a training session, the allotted dosage was provided. The subjects were instructed to take the capsules before their exercise and only with water. On non-training days instructions were to take the supplement as far from meals as possible and again only with water.⁸

D. Statistical Analysis

To give a comprehensive view of the collected data the means and standard deviations of the test variables are presented. In order to determine if significant differences (0.05 level) existed, a 2 x 3 factorial design with repeated measures on the second factor was used. Comparisons were made between the training with placebo group (N=4) and the training supplemented with wheat germ oil group (N=4). The first factor involved a comparison between the groups receiving the wheat germ oil dietary supplement and the non-nutritive placebo. The second or repeated factor dealt with the effects of training. In this case the same subjects were tested at three time periods (i.e. the levels), T_1 the pre-experimental test, T_2 after 5

⁸T. K. Cureton, "Physical Fitness: How to Earn it and Keep it with some Relationship to Nutrition," Journal of Physical Education, 54:3-14, 1956.

weeks of training with the addition of the dietary supplements, and T_3 subsequent to 10 weeks of training plus the dietary supplement.

Dayton has stated that repeated measures designs are utilized with one of three purposes being considered. The first involves comparisons of homogeneous material while matching a subject with himself. Of second consideration is that a reduced number of subjects are needed when repeated measures are used. The third purpose gives advantage to this design in experiments that include the passage of time as one of the treatment dimensions.⁹ The design of this investigation was such that it incorporated all three of the above purposes.

⁹C. Mitchell Dayton, The Design of Educational Experiments (New York: McGraw-Hill Book Co., 1970), pp. 244-68.

CHAPTER IV

ANALYSIS OF DATA AND DISCUSSION OF RESULTS

During the course of this investigation raw data were collected on each subject at three separate times. This chapter summarizes the statistical analysis of this data and is composed of two major divisions. The first major section is concerned with the statistical analysis. The second portion of the chapter includes a discussion of results of the present investigation as well as comparisons of the findings with those of previous studies.

A. Results of Statistical Analysis

1. Test-Retest Reliability

Six subjects were tested to determine the test-retest reliability of the variables used. All of the subjects were active and engaged in an endurance training program.* The subjects were tested twice with a one week interval between tests. The procedure and conditions were the same as those used in the administration of the study (see Appendix A). The Pearson Product-Moment Correlation was used to determine the coefficient of correlation between the successive test administrations. A paired "t" test was also used to determine if there was a significant difference between the means.

The reliability coefficients are shown in Table 1. The coefficients ranged from 0.85 to 0.96. In light of values reported by other investigators

*The training program engaged in was basically the same as that of the thesis subjects.

these were considered acceptable. Results of the paired "t" test are also shown in Table 1. No significant differences were found between the means.

2. Descriptive Statistics

a. Resting T-wave. The descriptive statistics concerning the T-wave amplitude are presented in Table 2. The mean T-wave amplitude of the wheat germ oil supplemented group was 7.66 mm. for the pre-experimental recording T_1 , before the first session of controlled training was begun. The T_1 standard deviation was 3.66 mm. After five weeks of training and being fed wheat germ oil the mean and standard deviation for T-wave amplitude was 7.38 and 4.25 mm., respectively. Subsequent to an additional five weeks of the experimental procedure the wheat germ oil group produced a mean T-wave amplitude of 8.95 mm. with a standard deviation of 3.33 mm.

The descriptive statistics for the initial test of the placebo supplemented group included a mean and standard deviation for T-wave amplitude of 7.86 and 3.61 mm. After five weeks of training plus the placebo an average T-wave amplitude of 8.91 mm. was elicited with a standard deviation of 3.99. Subsequent to 10 weeks of training plus the placebo, a mean T-wave amplitude of 8.65 mm. with a standard deviation of 2.67 resulted.

b. Immediate Post-Exercise T-wave. The descriptive statistics concerning the data for the post-exercise condition are presented in Table 3. The average T-wave amplitude of the wheat germ oil supplemented group was 10.95 mm. for the pre-experimental recording T_1 , before the first session of controlled training was begun. The standard deviation at T_1 was 3.90 mm. Following a five week training period with the addition of wheat germ oil

Table 1
Test-Retest Reliability

Test	Variable T-Wave			
	Rest	Immediate Post-Exercise	5 Minutes Post-Exercise	10 Minutes Post-Exercise
$r_{1,2}$	0.96	0.85	0.95	0.96
"t"	.17	.62	.50	.57

the mean T-wave amplitude was 11.65 mm. with a standard deviation of 4.72 mm. After an additional five weeks of the experimental procedure the wheat germ oil group produced an average T-wave amplitude of 11.34 mm. with an associated standard deviation of 4.52 mm.

The T_1 descriptive statistics for T-wave amplitude within the placebo supplemented group were a mean of 11.08 mm. and a standard deviation of 4.40 mm. At the conclusion of five weeks of training with the addition of the placebo the mean and standard deviation were 13.88 and 6.12 mm., respectively. Ten weeks of training plus the placebo resulted in a mean T-wave amplitude of 14.07 mm., and a standard deviation of 4.43 mm.

c. Five Minute Post-Exercise T-wave. The descriptive statistics concerning the T-wave amplitude are presented in Table 4. The mean T-wave amplitude of the wheat germ oil supplemented group was 7.36 mm. for the pre-experimental recording T_1 . The standard deviation at T_1 was 4.56 mm. After five weeks of training with the addition of wheat germ oil the respective mean and standard deviation for T-wave amplitude were 6.45 and 3.69 mm. Subsequent to 10 weeks of the experimental procedure the wheat germ oil group produced an average T-wave amplitude of 7.43 mm. with a standard deviation of 3.29.

At the initial test the mean and standard deviation for the T-wave amplitude of the placebo group were 6.63 and 3.19 mm., respectively. At T_2 the respective mean and standard deviation were 8.66 and 4.08 mm., respectively. Ten weeks of training plus the placebo resulted in a mean T-wave amplitude of 8.49 mm. and an associated standard deviation of 2.39 mm.

Table 2

Descriptive Statistics for Resting T-wave Amplitude*

Group	Value	Time of Test Administration		
		T ₁	T ₂	T ₃
Wheat Germ Oil	\bar{x}	7.66	7.38	8.95
	s	3.66	4.25	3.33
Placebo	\bar{x}	7.86	8.91	8.65
	s	3.61	3.99	2.67

*All values reported in millimeters.

Table 3

Descriptive Statistics for Immediate
Post-Exercise T-wave Amplitude*

Group	Value	Time of Test Administration		
		T ₁	T ₂	T ₃
Wheat Germ Oil	\bar{x}	10.95	11.65	11.34
	s	3.90	4.72	4.52
Placebo	\bar{x}	11.08	13.88	14.07
	s	4.40	6.12	4.43

*All values reported in millimeters.

d. Ten Minute Post-Exercise T-wave. The descriptive statistics concerning the T-wave amplitude are presented in Table 5. The average T-wave amplitude of the wheat germ oil supplemented group was 8.15 mm. for the pre-experimental recording. The standard deviation at this time was 4.69 mm. After five weeks of training and being fed wheat germ oil the average T-wave amplitude was 6.99 mm. with a standard deviation of 4.01 mm. Ten weeks of the experimental procedure produced a mean and standard deviation for average T-wave amplitude of 7.86 and 3.02 mm.

The descriptive statistics of the placebo supplemented group at T_1 were an average T-wave amplitude of 6.82 mm. and a standard deviation of 3.03. At the conclusion of five weeks of training with the addition of the placebo the mean and standard deviation were 8.78 and 3.46 mm., respectively. Ten weeks of training plus the placebo resulted in a mean T-wave amplitude of 9.12 mm. and a standard deviation of 2.84 mm.

3. Inferential Statistics

The data gathered during the three test administrations for the wheat germ oil group ($N=4$) and the placebo group ($N=4$) were statistically analyzed to determine if any significant differences existed between the groups. The statistical technique used was a 2 x 3 factorial design with repeated measures on the second factor.

a. Resting T-wave. A non-significant F-ratio of .04 indicated no beneficial effects of the dietary supplements on T-wave amplitude. In regard to the effects of training on T-wave amplitude a resulting F-ratio of 1.91

Table 4
Descriptive Statistics for Five Minute
Post-Exercise T-wave Amplitude*

Group	Value	Time of Test Administration		
		T ₁	T ₂	T ₃
Wheat Germ Oil	\bar{x}	7.36	6.45	7.43
	s	4.56	3.69	3.29
Placebo	\bar{x}	6.63	8.66	8.50
	s	3.19	4.08	2.39

*All values reported in millimeters.

Table 5
Descriptive Statistics for Ten Minute
Post-Exercise T-wave Amplitude*

Group	Value	Time of Test Administration		
		T ₁	T ₂	T ₃
Wheat Germ Oil	\bar{x}	8.15	6.99	7.86
	s	4.69	4.01	3.02
Placebo	\bar{x}	6.82	8.78	9.12
	s	3.03	3.46	2.84

*All values reported in millimeters.

failed to reveal any significant changes. For the interaction of the training and dietary supplementation the computed value of F was 1.55 which was not significant and indicated a lack of significant interaction between the training and dietary supplement. The summary table for this analysis is presented in Table 6.

b. Immediate Post-Exercise T-wave. A non-significant F -ratio of .27 indicated no beneficial effects of the dietary supplements on immediate post-exercise T-wave amplitude. In regard to the effects of training on T-wave amplitude, a resulting F -ratio of 4.27 was significant and indicated a desirable increase in amplitude. A post-hoc test, Student-Newman-Keuls, revealed the T-wave amplitude was significantly greater after 5 and 10 weeks of training as compared to those at the beginning of the study. For the interaction of the training and dietary supplementation the computed value of F was 2.05 which was not significant and indicated a lack of meaningful interaction between the training and dietary supplement. See Table 7 for a summary of the ANOVA computation.

c. Five Minute Post-Exercise T-wave. For this test condition no effects of the dietary supplements were exhibited as a non-significant F -ratio of .13 resulted. In regard to the effects of training on T-wave amplitude, a resulting F -ratio of .78 was not significant thus failed to reveal any meaningful changes. For the interaction of the training and dietary supplementation the computed value of F was 1.83 which indicated a lack of significant interaction between the training and dietary supplement. See Table 8 for a summary of the computation.

Table 6

Analysis of Variance Summary Table on Resting
T-wave Amplitude

Source	df	Sum of Squares	Mean Square	F
Among Subjects	7			
B (Diet)	1	1.35	1.35	.04
S (Subjects)	6	221.08	36.85	
Within Subjects	16			
A (Training)	2	4.42	2.21	1.91
AB	2	3.59	1.80	1.55
AS	12	13.89	1.16	
Total	23	21.90		

Critical F ratio ($\alpha = .05$, $df = 1/6$) = 5.99.
 Critical F ratio ($\alpha = .05$, $df = 2/12$) = 3.89.

Table 7

Analysis of Variance Summary Table on Immediate
Post-Exercise T-wave Amplitude

Source	df	Sum of Squares	Mean Square	F
Among Subjects	7			
B (Diet)	1	17.34	17.34	.27
S (Subjects)	6	380.77	63.46	
Within Subjects	16			
A (Training)	2	15.76	7.88	4.27 *
AB	2	7.57	3.79	2.05
AS	12	22.16	1.85	
Total	23	45.49		

Critical F ratio ($\alpha = .05$, $df = 1/6$) = 5.99.

*Critical F ratio ($\alpha = .05$, $df = 2/12$) = 3.89.

Table 8

Analysis of Variance Summary Table on Five-Minute
Post-Exercise T-wave Amplitude

Source	df	Sum of Squares	Mean Square	F
Among Subjects	7			
B (Diet)	1	4.33	4.33	.13
S (Subjects)	6	204.30	34.05	
Within Subjects	16			
A (Training)	2	3.73	1.86	.78
AB	2	8.80	4.40	1.83
AS	12	28.82	2.40	
Total	23	41.35		

Critical F ratio (α = .05, df = 1/6) = 5.99.

Critical F ratio (α = .05, df = 2/12) = 3.89.

d. Ten Minute Post-Exercise T-wave. A non-significant F-ratio of .06 for the ten minute post exercise period failed to reveal any effects of the dietary supplements on T-wave amplitude. In regard to the effects of training on T-wave amplitude, a resulting F-ratio of 1.07 was not significant thus indicated no changes. A lack of significant interaction between the training and dietary supplement was evidenced as the computed value of F was 2.90 which was not significant. A summary of this ANOVA computation is presented in Table 9.

Table 9

Analysis of Variance Summary Table on Ten-Minute
Post-Exercise T-wave Amplitude

Source	df	Sum of Squares	Mean Square	F
Among Subjects	7			
B (Diet)	1	1.97	1.99	.06
S (Subjects)	6	205.99	34.33	
Within Subjects	16			
A (Training)	2	4.12	2.06	1.07
AB	2	11.18	5.59	2.90
AS	12	23.13	1.93	
Total	23	38.44		

Critical F ratio ($\alpha = .05$, $df = 1/6$) = 5.99.

Critical F ratio ($\alpha = .05$, $df = 2/12$) = 3.89.

B. Discussion of Results

The results of this investigation can be divided into two basic areas for discussion. The first area of consideration is concerned with the effects of training on the precordial T-wave. Discussion of the effects of wheat germ oil on the precordial T-wave is the second area.

1. Effects of Training on the Precordial T-wave

One of the treatments incorporated in the experiment was a strenuous physical training program for both the wheat germ oil supplemented group and the placebo group. Taking into consideration results reported in previous studies,^{1,2,3,4,5} the investigator anticipated a significant increase in T-wave amplitude due to the exercise under all the test conditions administered. The results of the investigation revealed a significant increase

¹E. L. Cooper, J. O'Sullivan, and E. Hughes, "Athletics and the Heart: An Electrocardiographic and Radiological Study of the Response of the Health and Diseased Heart to Exercise," Medical Journal of Australia, 1:569-79, April, 1937.

²George L. Beckner and Travis Winsor, "Cardiovascular Adaptations to Prolonged Physical Effort," Circulation, 9:835-46, June, 1954.

³T. K. Cureton, "Effects of Longitudinal Physical Training on the Amplitude of the Highest Precordial T-wave of the ECG," Medicina Sportiva, 12:259-81, 1958.

⁴Forbes Carlile and Ursula Carlile, "T-wave Changes in the Electrocardiogram Associated with Prolonged Periods of Strenuous Exercise in Sportsmen with Special Reference to Application in Training Swimmers," Australian Journal of Physical Education, 17:10-20, 1959.

⁵Fernand R. Plas, "Electrocardiographic Changes during Work and Prolonged Effort," Journal of Sports Medicine and Physical Fitness, 3:131-36, 1963.

in T-wave amplitude only in the immediate post exercise conditions. The one reported significant mean gain was in agreement with investigations by Cooper, O'Sullivan, and Hughes,⁶ Beckner and Winsor,⁷ Cureton,⁸ Carlile and Carlile,⁹ and Plas.¹⁰ Examining more closely, the study by Cooper, O'Sullivan and Hughes, the authors expressed considerable doubt relative to the physiological causes of variations in electrocardiographic tracings. The investigators reported increased amplitude in all the deviations of the athletes ECGs and especially the T-waves, but they later stated that this was a common feature in both the untrained and trained man. Recordings taken immediately after exercise revealed an increase in T-wave amplitude in some subjects while others showed a decrease. The authors felt that training affected the electrocardiogram but it was not to a great extent or permanent.¹¹

Beckner and Winsor studied the cardiovascular system of male marathon runners who had been training for at least five years. Etiologically, an enlarged heart had resulted. The underlying assumption being that prolonged physical exercise of the intensity required for running 26 miles had resulted in chronic and acute physiological adaptations. The authors

⁶Cooper, O'Sullivan, and Hughes, loc. cit.

⁷Beckner and Winsor, loc. cit.

⁸Cureton, loc. cit.

⁹Carlile and Carlile, loc. cit.

¹⁰Plas, loc. cit.

¹¹Cooper, O'Sullivan and Hughes, loc. cit.

compared the electrocardiograms of these marathon runners with a group of non-runners. As expected, the electrocardiograms of the trained runners revealed adaptations of greater magnitude than those of the control group and greater than those considered to be within normally accepted limits.¹²

In analyzing the study by Cureton concerning the effects of longitudinal physical training on T-wave amplitude it should be noted that the author did not actually undertake an experiment to reveal these effects. Instead, a summary report of previously completed studies was presented. The studies were such that their primary intent dealt with other considerations or they involved case studies. This is not to imply that a true representation of the data from these studies was not presented, however, more valid information would have probably been forthcoming if experiments specifically concerned with these factors had been undertaken.¹³

The study by Carlile and Carlile probably offers the greatest amount of support of T-wave changes due to varying degrees of exercise. The investigators employed over 100 subjects and made over 500 electrocardiographic recordings during a six month experimental period. The recordings were made under various experimental conditions to determine the effects of different training intensities, the effect of chronic fatigue, and the prolonged effects of these factors. The changes were reported to be relative to the intensity of the training program, and closely related to the degree of strenuous exercise the subjects underwent during a particular test phase. Mild training produced no noticeable changes, whereas overtraining depressed

¹²Beckner and Winsor, loc. cit.

¹³Cureton, loc. cit.

T-wave amplitude. The correct progressive intensity brought about a gradual increase in amplitude. Subjection to intense physical exertion resulted in a flat or depressed T-wave that sometimes took months to return to normal.¹⁴

The study on electrocardiographic changes during work and prolonged effort by Plas was more from the viewpoint of medical aspects than training or conditioning. The author stated that T-wave amplitude was relative to physical efficiency, but the original intent was to reveal to others in the field that abnormal electrocardiograms of athletes should not always be interpreted as organic heart disease.¹⁵

All of the above mentioned studies seemed to indicate that exercise resulted in increased T-wave amplitude. Further examination revealed the possibility of this not always being the case. An explanation of this could be due to a variety of circumstances relative to the designs and subjects used. Taking these facts into consideration the original anticipation of increased T-wave amplitude as a consequence of training under all of the test conditions may have been unwarranted.

Observation of the immediate effects of exercise on T-wave recordings indicates the results of the present investigation to be in fact parallel to the findings of an electrocardiographic study by Joseph. Joseph's investigation was primarily concerned with variations in T-wave amplitude as caused by exercise. The investigator collected electrocardiograms on subjects at rest, during exercise on a treadmill, and at specified minutes (1-10)

¹⁴Carlile and Carlile, loc. cit.

¹⁵Plas, loc. cit.

during recovery from the treadmill exercise.¹⁶ The procedure of test administration for the present study was essentially the same. Joseph graphed the mean heights of the T-waves recorded. The same has been done for the present investigation (see Figure 4). As can be seen by the graphical representations, the exercise-influenced T-wave increases greatly during and immediately after exercise. Upon termination of the exercise the T-wave gradually decreases until approximately the fifth minute of elapsed recovery time. During the remaining elapsed time there is a gradual increase in T-wave height until it closely correlates with the previously recorded resting amplitude.¹⁷ The graphical representations reveal that the same basic pattern of fluctuation of T-wave amplitude was evidenced in both studies.

2. The Effects of Wheat Germ Oil on the Precordial T-wave

The hypothesis that the consumption of wheat germ oil by runners involved in a high intensity training program would result in increased cardiovascular efficiency, notably increased amplitude of the precordial T-wave, was not supported in this study. This was in direct contradiction to

¹⁶Jack J. Joseph, "The Exercise-Influenced T-wave and its Relation to Sustained Treadmill Running," Journal of Sports Medicine, 10:91-95, 1970.

¹⁷Ibid.

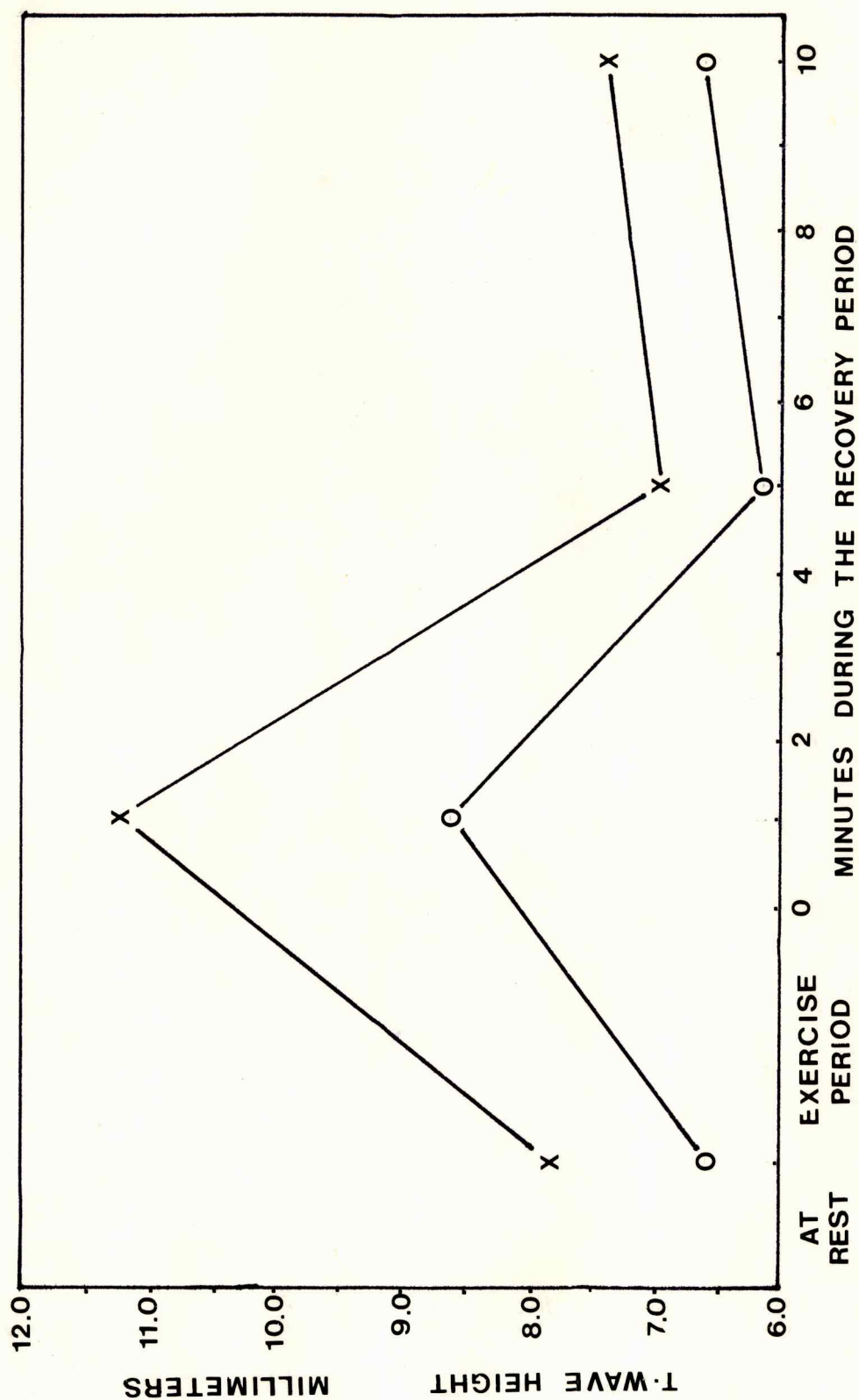


Figure 4

A Graphical Representation of T-wave Amplitude
Legend: Joseph Study O; Present Study X

the findings of Forr,¹⁸ Susic,¹⁹ and Mayhew.²⁰ Other investigators^{21,22,23,24,25,26} have also used the precordial T-wave either as one of numerous tests of cardiovascular fitness or as the primary test when trying to

¹⁸William A. Forr, "The Effects of Wheat Germ Oil (Vitamin E) on Physical Fitness" (unpublished Master's thesis, University of Illinois, 1950), pp. 66-70.

¹⁹Steve Susic, "The Effect of Training and Dietary Supplement on the T-wave of the ECG at Ground Level and at 10,000 Feet of Simulated Altitude" (unpublished Master's thesis, University of Illinois, 1953), p. 50.

²⁰Jerry L. Mayhew, "The Effects of Training with and without Wheat Germ Oil on the T-wave of the Electrocardiogram and Other Selected Fitness Measures of Middle-Aged Men" (unpublished Master's thesis, University of Illinois, 1967), pp. 31-97.

²¹T. K. Cureton and R. H. Pohndorf, "Influence of Wheat Germ Oil as a Dietary Supplement in a Program of Conditioning Exercises for Middle-Aged Subjects," Research Quarterly, 26:391-407, December, 1955.

²²Arthur F. Maley, "The Effects of Training and a Dietary Supplement on the Cardiovascular Fitness of Adult Men" (unpublished Master's thesis, University of Illinois, 1952), p. 36, cited by T. K. Cureton, The Physiological Effects of Wheat Germ Oil on Humans in Exercise (Springfield, Illinois: Charles C. Thomas Publishers, 1972), pp. 346-50.

²³William J. Vohoska, "The Effects of Wheat Germ Oil on the Cardiovascular Fitness of Varsity Wrestlers" (unpublished Master's thesis, University of Illinois, 1954), p. 43, cited by T. K. Cureton, The Physiological Effects of Wheat Germ Oil on Humans in Exercise (Springfield, Illinois: Charles C. Thomas Publishers, 1972), pp. 351-52.

²⁴Edmund M. Bernauer, "The Influence of Wheat Germ Oil as a Dietary Supplement in a Training Program of Varsity Track Athletes at the University of Illinois" (unpublished Master's thesis, University of Illinois, 1958), cited by T. K. Cureton, The Physiological Effects of Wheat Germ Oil on Humans in Exercise (Springfield, Illinois: Charles C. Thomas Publishers, 1972), pp. 402-10.

²⁵T. K. Cureton, "Improvement in Physical Fitness Associated with a Course of U.S. Navy Underwater Training, with and without Dietary Supplements," Research Quarterly, 34:440, December, 1963.

²⁶Robert M. Poiletman and Harry A. Miller, "The Influence of Wheat Germ Oil on the Electrocardiographic T-waves of the Highly Trained Athlete," Journal of Sports Medicine and Physical Fitness, 8:26-33, March, 1968.

differentiate the effects of the dietary supplement. Given this fact, studies reporting only within group significant gains in T-wave amplitude are of questionable validity since previous investigations^{27,28} have shown an endurance training program of the correct dosage produces increased amplitude. Therefore, gains in T-wave amplitude are expected and not necessarily due to the addition of the wheat germ oil dietary supplement. Taking into special consideration the T-wave results in an investigation by Cureton and Pohndorf²⁹ the changes were due to the effects of training and not the addition of wheat germ oil. The non-significant differences reported in this study are in agreement with the findings of Maley,³⁰ Vohoska,³¹ Bernauer,³² a later wheat germ oil study by Cureton,³³ and Poiletman and Miller.³⁴ The writer fully realizes that studies reporting trends in favor of the dietary supplement such as the reported trends in the investigation by Poiletman and Miller,³⁵ are usually presented as support of the effects

²⁷Carlile and Carlile, loc. cit.

²⁸T. K. Cureton, "The Effects of Longitudinal Physical Training on the Amplitude of the Highest Precordial T-wave of the ECG," loc. cit.

²⁹Cureton and Pohndorf, loc. cit.

³⁰Maley, loc. cit.

³¹Vohoska, loc. cit.

³²Bernauer, loc. cit.

³³Cureton, "Improvement in Physical Fitness Associated with a Course of U.S. Navy Underwater Trainees with and without Dietary Supplements," loc. cit.

³⁴Poiletman and Miller, loc. cit.

³⁵Ibid.

of the dietary supplement. In light of the results lacking statistical significance the writer feels that Poiletman and Miller's³⁶ data were in agreement with those of this investigation but that their questionable interpretations lead to variant conclusions.

³⁶Ibid.

CHAPTER V

SUMMARY, CONCLUSIONS, AND RECOMMENDATIONS

A. Summary

The purpose of this study was to determine the effects of a high intensity training program with and without wheat germ oil on the cardiovascular efficiency of cross-country runners. The index of cardiovascular efficiency utilized was the T-wave amplitude of the electrocardiogram as recorded from the precordial position.

Eight members of the Appalachian State University cross-country team were used as subjects. The subjects ranged in age from 18 to 24 years and were divided into two equal groups based on their initial T-wave recordings. One group (N=4) took wheat germ oil (10 capsules per day, six minims each) as a dietary supplement. The other group (N=4) took a non-nutritive placebo (10 capsules per day). The capsules were ingested prior to each day of training with the dietary supplements being administered on a double blind basis.

Using a Burdick EK 4 dual speed electrocardiogram the subjects were tested at the beginning of formal training (T_1), at the conclusion of five weeks of training (T_2), and following ten weeks of training (T_3). The training was of the type required in a conditioning program for college level cross-country runners. The testing was done in the University Medical Center. The electrocardiographic tests were recorded in the precordial

position (lead V_4) under the following conditions: (1) reclining rest; (2) 30 seconds after a bench-stepping exercise; (3) five minutes following the bench-stepping exercise; and (4) ten minutes following the bench-stepping exercise. The bench-stepping exercise was performed at a rate of 30 steps per minute for five minutes on a 17-inch bench.

Standard descriptive statistics consisting of means and standard deviations of T-wave amplitude were derived from the electrocardiographic recordings. A 2 x 3 factorial design with repeated measures on the second factor was used for analysis of the T-wave amplitude data. The analysis revealed no significant differences in regard to the effects of the dietary supplements. Analysis of data relative to the effects of training on T-wave amplitude revealed a significant gain only in the immediate post exercise reading. The significant gain, as shown by the Student-Newman-Keuls post hoc test, was subsequent to the T_2 and T_3 experimental periods as compared to the T_1 test data. Finding no significant results with the addition of the dietary supplement, and revealing only one instance of a significant gain due to the effects of training, was not in complete support of results of previous research.

The lack of agreement relative to gains in T-wave attributable to training may have been due to limited control of the subjects used in this investigation. As was discussed in Chapter IV, however, evidence of this occurrence was not entirely convincing. Consideration of the failure to demonstrate significant alterations in T-wave amplitude subsequent to the ingestion of wheat germ oil must be done with caution. The results of the present investigation are in agreement with those studies reporting statistically non-significant effect which seems to further substantiate this approach.

B. Conclusions

Within the scope of this study, the following conclusions appear to be justified:

1. The addition of the wheat germ oil dietary supplement as compared to a placebo to a high intensity training program produced no significant changes in T-wave amplitude after a 5 and 10 week experimental period.
2. The high intensity training program produced a significant gain in T-wave amplitude in the immediate post-exercise recording following a 5 and 10 week training period.
3. No significant gains in T-wave amplitude due to training were revealed in the resting T-wave condition, the five minute post-exercise condition, or the ten-minute post exercise condition.
4. No significant interaction between the training and dietary supplement was evidenced.

C. Recommendations

As a result of the experience gained and insight developed during the course of this investigation on the effects of a high intensity training program with the addition of a dietary supplement on the precordial T-wave of cross country runners, the following suggestions for further investigation are proposed:

1. Through the use of an increased sample size the comprehensiveness of the study could be greatly expanded. Due to practical considerations,

this would probably require the incorporation of subjects from an area within which two or three colleges, universities or clubs are located.

2. Further investigations should be conducted over a longer time period. The extended period including: (a) a prescribed conditioning phase involving all subjects; (b) a lengthened training phase between the initial test administered T_1 and the second or mid-experimental check T_2 ; (c) a longer training phase between T_2 and the final test, T_3 .

3. The elimination of the possible psychological effects would be minimized if the wheat germ oil capsule and placebo supplied were less discernible in regard to physical appearance.

4. Further investigation relative to biological evaluation of the supposed known and unknown nutrients contained in wheat germ oil should be made and their pharmacologic effects analyzed.

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APPENDICES

APPENDIX A

SUBJECT DATA

Subject	Age	Height	Weight		
			T-1	T-2	T-3
T. Clark	24.25	71.00	160.0	158.0	160.0
J. Driver	20.41	70.00	140.0	147.0	142.0
J. Gaddy	18.25	70.00	152.0	149.0	146.0
D. McElroy	21.08	69.50	147.0	145.0	146.0
S. Pittman	18.50	67.50	133.0	125.0	133.0
C. Stanley	21.58	73.00	173.0	169.0	169.0
J. Thomas	18.08	70.50	145.0	145.0	141.0
S. Whicker	19.75	68.00	119.0	128.0	122.0

APPENDIX B

TEST PROTOCOL

Minutes	Subject Procedure
0:00 - 15:00	Reclining Rest.
15:00 - 16:00	Confirm electrode placement.
16:00 - 16:15	Resting ECG recording.
16:15 - 17:00	Stand in position in front of bench.
17:00 - 22:00	Bench Stepping (30 steps/min.).
22:00 - 22:30	Immediate Post-Exercise ECG Recording (reclining position).
22:30 - 27:30	Reclining Rest.
27:30 - 28:00	Five Minute Post-Exercise ECG Recording (reclining position).
28:00 - 33:00	Reclining Rest.
33:00 - 33:30	Ten Minute Post-Exercise ECG Recording (reclining position).

APPENDIX C

ASU CROSS-COUNTRY TRAINING PROGRAM

Example of a Two Week Period of Workouts*

<u>Monday</u>	<u>Tuesday</u>	<u>Wednesday</u>	<u>Thursday</u>	<u>Friday</u>	<u>Saturday</u>	<u>Sunday</u>
Continuous Running. 7:00-8:00 per mile pace. 5-10 miles on your own.	Interval. 2 mile jog warm up. 20 x 440 (1:30 rest int.). 2 mile jog wrm. dwn.	Continuous Running. 7:00-8:00 per mile pace. 7 miles over hilly and rough terrain.	Interval. 3.7 mile warm up. 4 x 1320 (4:00 rest int.). 3.7 mile wrm. dwn.	Continuous Running. 7:00-8:00 per mile pace. 7-9 miles.	Interval. 2 mile warm up. 32 x 220 (45 sec. rest int.). 2 mile wrm. dwn.	Rest or Slow Continuous Running on your own.
<u>Monday</u>	<u>Tuesday</u>	<u>Wednesday</u>	<u>Thursday</u>	<u>Friday</u>	<u>Saturday</u>	<u>Sunday</u>
Interval. 2 mile jog warm up. 1 x 2 miles down hill (faster than race pace). 1 x 1 mile flat 3 miles warm dwn.	Continuous Running. 1-1½ hr. run.	Interval. 2 miles jog. 6 x 660 (1:45 rest int.). 10 x 330 (1:45 rest int.). 2 miles wrm. dwn.	Continuous Running. 7:00-8:00 per mile pace. 6-11 miles.	Rest or 2-3 miles jog, stretching, loosening up.	Usual day of competition.	Rest or easy continuous running.

*Each subject participated as regularly as possible in all workouts. These are actual workouts with consideration given to the individuality of each runner. The considerations were along the lines of the pace for the interval runs being based on a five mile run time and relative to fatigue.

APPENDIX D

SUBJECT T-WAVE DATA

Subject		Condition		
		Reclining Rest*	Imm. Post-Ex.	5-Min. Post-Ex. 10-Min. Post-Ex.
T. Clark	T ₁	6.96	6.69	4.41 4.56
	T ₂	5.76	5.74	3.75 4.35
	T ₃	8.08	5.75	5.30 6.18
J. Driver	T ₁	7.90	13.58	12.02 12.70
	T ₂	8.57	14.11	7.72 8.22
	T ₃	8.50	16.34	8.08 8.52
J. Gaddy	T ₁	7.32	8.58	5.68 6.52
	T ₂	10.62	11.32	10.54 10.12
	T ₃	7.92	13.70	7.15 7.83
D. McElroy	T ₁	10.90	9.47	8.42 8.53
	T ₂	12.85	12.86	11.42 11.29
	T ₃	11.97	11.96	11.30 12.76

*All measurements in millimeters.

APPENDIX D (Continued)

Subject		Reclining Rest*	Condition		
			Imm. Post-Ex.	5-Min. Post-Ex.	10-Min. Post-Ex.
S. Pittman	T ₁	2.97	8.62	2.61	2.68
	T ₂	3.51	8.66	2.60	3.67
	T ₃	5.54	10.24	5.97	6.13
C. Stanley	T ₁	3.51	8.66	2.60	3.67
	T ₂	2.58	10.22	3.23	3.29
	T ₃	5.64	10.05	4.53	4.93
J. Thomas	T ₁	12.28	14.85	10.42	11.65
	T ₂	12.59	16.52	11.09	12.09
	T ₃	13.58	13.20	11.79	11.80
S. Whicker	T ₁	10.24	17.66	9.82	9.53
	T ₂	8.64	22.68	10.08	10.05
	T ₃	9.16	20.36	9.55	9.76

*All measurements in millimeters.

VITA

Name: Donald Earl Kennedy.

Permanent address: Rt. 8, Box 226, Fayetteville, North Carolina 28304.

Degree and date to be conferred: M.A., 1973.

Date of birth: December 23, 1947.

Place of birth: Fayetteville, North Carolina.

Secondary education: Seventy-First High School, 1966.

Collegiate institutions attended	Dates	Degree	Date of Degree
Appalachian State University	1966-70	B.S.	June, 1970
Appalachian State University	1970-73	M.A.	August, 1973

Major: Physical Education.

Minor: Junior College Education, Secondary Education.

Publications: D. E. Kennedy and J. L. Mayhew, "Electrocardiographic T-wave Changes with Heavy Exercise," British Journal of Sports Medicine, 5:198-204, July, 1971.

Positions held: Army, Instructor and Competitor, Orienteering Team.
ASU Graduate Assistant Coach, Track and Cross-Country.