

A STUDY OF THE CARDIOVASCULAR PHASE
OF THE 1970 KANSAS STATE UNIVERSITY
CROSS COUNTRY PROGRAM

by G32

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INTRODUCTION

Each year during the latter part of summer, cross country coaches begin preparing their teams for the up-coming season. The short duration of the cross country campaign in the United States places a strong emphasis on the formulation of maximal productive workouts. The nature of a collegiate four- to six-mile race requires that the successful competitor be trained to resist fatigue. Karpovich believes that the key to this training is to provide for the increasing oxygen demands of the muscle cells in order for them to carry on oxidation processes necessary in metabolism to produce the additional energy required for prolonged exertion. This resistance capability is possible only through the conditioning of the oxygen transport or cardiovascular system.¹ Steinhaus defines endurance as distance from fatigue and further explains:

Since oxygen can come to the muscles only via the blood system, it is obvious that any adjustment that increases the amount of blood going to the exercising muscles will thereby postpone fatigue and by so doing increase endurance.²

Dunaway suggests the following in regard to the importance of cardiovascular training for cross country runners:

Thus increasingly, as the distance lengthens, the ability to run fast and win depends on the ability of the heart and blood stream to deliver enough oxygen to keep up with muscular activity. The more oxygen delivered, the faster will be the steady pace of the runner - that is, the more stamina he has.³

Therefore, cross country coaches seek to identify those cardiovascular qualities that are beneficial to running. Down states that these qualities include the transportation of oxygen to the tissues, the development of a rapid blood flow coupled with greater stroke-volume, and the increase in cardiac output along with reduced pulse rate.⁴

Travers emphasizes the importance of these qualities:

An efficient blood supply to the muscle is necessary for the greatest muscular effort; firstly to carry oxygen and glucose to the muscles and secondly to remove carbon dioxide and breakdown products of muscular effort from them. During training the ability of the heart and blood vessels to cope with increasing demands is established.⁵

The fact that the heart and blood are primarily responsible for oxygen transportation is established. The reality that the improvement of their functioning is the critical factor in the training for cross country runners is becoming increasingly evident.

PURPOSES OF THE PROBLEM

The purpose of this problem is three-fold. The first purpose is to explain and emphasize the importance of cardiovascular training for cross country runners in general. The second purpose is to relate the principles governing the cardiovascular training of the Kansas State University cross country team. The third purpose is to theoretically evaluate the 1970 Kansas State University cross country program in regard to cardiovascular conditioning.

METHOD OF STUDY

In order to explain and evaluate cardiovascular training, it was decided to conduct a thorough investigation of the works of authorities in the field. Consequently, a search and review of the literature in the Kansas State University libraries, the personal libraries of professional colleagues, and the personal books, clinic notes, and journals of the author was executed. Working with the Kansas State University varsity cross country practice sessions has been of great

benefit in preparing an explanation and evaluation of the cardiovascular phase of that specific program.

LIMITATIONS OF STUDY

Although most works written by coaches expound on philosophy and general formats of practice sessions, few cover in any depth the cardiovascular phase of their programs. More of this information would be valuable to cross country coaches seeking further help in this area.

DEFINITION OF TERMS

An understanding of the terminology of cardiovascular training is possibly of value to the investigator of this subject. For this reason the following terms are defined:

Aerobic:	This pertains to metabolism in the cell when there is an adequate amount of oxygen present.
Capillary:	The minute blood vessel that arises from an artery and is located throughout the body tissue to deliver the needed nutrients.
Cardiac Output:	The amount of blood pumped by the heart.
Cardiac Hypertrophy:	The increase in size of the heart.
Cardiovascular System:	The word <u>cardio</u> pertains to the heart, and <u>vascular</u> refers to the blood vessels. Therefore, the cardiovascular system involves the heart that pumps

the blood and the blood vessels that provide transportation pathways for the pumped blood.

Crest Load:

The maximum work state in which oxygen intake is equal to the expenditure of oxygen.

Cross Country:

A competitive sport involving the footrace of from four- to six-miles over varying terrain.

Endurance:

The ability to withstand fatigue.

Fatigue:

A state where muscular activity is seriously impeded due to an accumulation of non-volatile acids including lactic acid.

Interval Training:

This type of training involves repeatedly running a predetermined distance at a specified tempo with a prescribed time period separating each effort. The governing factor is the runner's pulse rate.

Kansas State University
Cross Country Program:

The specific training program used to condition cross country runners at Kansas State University. The entire program is presented in Table I.

Metabolism:

The chemical processes that occur in body cells.

Minute-Volume:	The amount of blood pumped by the heart per minute.
Overdistance Training:	This type of training involves running continually for a distance exceeding the length of the race for which the athlete is being conditioned.
Overload Principle:	This principle states that improvement in endurance is a result of a gradual increase in the intensity of the work.
Pulse Rate:	A wave of blood that flows along the arteries following each heart beat.
Second Wind:	The adjustments made to cope with the initial stress of exercise.
Steady State:	The state of work where the oxygen intake is equal to the amount of oxygen expended.
Stroke Volume:	The amount of blood pumped by the heart per heart beat.

RESULTS AND DISCUSSION

Attempting to determine the most ideal cross country training program from the literature studied was extremely difficult. One reason for this was because most of the authorities had produced the desired end result - champion cross country runners. The successful Kansas State

University cross country program was reviewed and evaluated with this positive factor in mind.

Fundamental Premises

The basis of the Kansas State University training program has been built around accepted premises. Fundamental to the program has been an understanding of the effect of the stress factor. Selye defined stress as "essentially the rate of the wear and tear on the body."⁶

Counsilman elaborated in the following explanation:

It is a physiological law that the body attempts to adapt to the specific stress placed upon it by changing itself in order that it might be better able to cope with this specific type of stress the next time it is imposed. It is important to note the word specific.⁷

Wilt divided adaptation to stress into the alarm stage, the resistance stage, and the stage of exhaustion.⁸ Counsilman advanced the idea that this adaptation to stress can be theoretically plotted through a fatigue zone, an adaptation zone, a super adaptation zone, and a failing adaptation zone.⁹ In reference to these concepts of adaptation stages or zones, the intensity of the stress used has become extremely important.

Basic to the determination of what intensity of stress to apply has been an understanding of the overload principle. De Vries offered the following explanation of this premise:

Whether we are concerned with strength, muscular endurance, or circulo-respiratory factors, improvement in function occurs only when the system involved is challenged. Improvement occurs when, and only when, the workload is greater than that to which an individual is accustomed.¹⁰

Waha discussed the application of the overload principle:

Progressive overload is generally achieved by varying the duration or the frequency of the exercise (repetition) or by increasing the intensity of the work.¹¹

Cooper, et. al. concurred that to be effective, training must be gradually increased and intensified.¹² Lawther also agreed that exercise intended to develop endurance should be carefully and gradually increased.¹³ Therefore, the gradual intensification of exertion in the Kansas State University workouts has been carefully prescribed.

Essential to this gradual progression of the Kansas State University program has been the resort to twice-a-day training sessions. Formichev and Fruktov stated:

Twice-a-day training permits one to increase the load. Moreover, a more frequent exchange of stages of work and rest promotes a better recovery of nervous and muscular energy. This is upheld by the research of Egolinski (1956), where it was found that during work on the arm erg-o-graph, the best results were obtained during conditions of two workouts a day.¹⁴

Another study related by Formichev and Fruktov demonstrated that pulse rate recovery time was considerably less in subjects who used two-a-day workouts than with a one-a-day workout control group. Thus, it was concluded that twice-a-day training was more effective in improving the cardiovascular system.¹⁵

Specific Cardiovascular Training Objectives

Several specific cardiovascular objectives were considered in the formulation of the Kansas State University cross country program. According to a specialist in the field, the primary physiological adjustments found in distance runners were the increase of the capillarization of the muscles and an increase in the efficiency of the heart.¹⁶ Also to be considered was a result of these adjustments which was labeled as an objective too. This result is an increase of the athlete's maximum steady state or crest load.

The constant, or steady, work load associated with cross country running was found to be predominately an aerobic exercise. Aerobic in this sense meant cell metabolism carried on with the availability of a sufficient amount of oxygen.¹⁷ It was related that during the performance of such a steady work load the athlete's cardiovascular activity, along with the other body functions, leveled off after the initial stress provided by the start of the race. When this leveling off occurred the runner was said to be exercising in the steady state. Having achieved this state the runner's oxygen intake, transported by the cardiovascular system, was equal to the expenditure of oxygen required by the exertion.¹⁸ As long as this steady state was maintained, the exercise intensity was considered to be within the scope of a normal load. Karpovich termed the greatest normal load as the crest load.¹⁹ The increase of the crest load of each runner was set forth as an objective of the Kansas State University program.

Another point to be considered in regard to the previous objective was the cardiovascular importance of the often discussed second wind. During prolonged or violent exertion some runners who felt fatigue also experienced a sudden sense of great relief. Ferguson explained it in this way:

When running at moderate speed (65 sec. quarters), about 75% of energy expenditure in skeletal muscles is lost as heat. The body temperature center in the runner's brain has possibly increased from two to four degrees, the center sends impulses to the vasodilation center for blood vessels in the after brain to relax the arteries and arterioles. Before this relaxation, the heart is struggling to move a large quantity of blood through tubes that are too small. After the relaxation, the back pressure has been removed from the heart and it suddenly finds its work easier. When this process occurs, the runner either abruptly or gradually enters his second wind (Ferguson reflex) depending upon how quickly the arterioles open.²⁰

Although there was not total agreement on the above explanation of second wind, it was the consensus of most authorities that neural circulatory, respiratory, and heat production adjustments were involved. Furthermore, the metabolic requirement of the exercising muscles was considered to be playing a determining role.²¹ Karpovich wrote that "Even the heart action may change, its beat becoming slower and more regular."²² In the same discussion Karpovich also pointed to improved peripheral circulation as an effect of second wind.²³ Therefore, the existence of second wind was well accepted; however, the importance of it was usually confined to athletes who were not yet in good cardiovascular condition. Roskamm, et. al. agreed:

Since well-trained runners seldom experience the second wind, it appears that the adjustments associated with this phenomenon are brought about during warm-up and prior to the start of intense running in the case of these athletes.²⁴

Therefore, the effect of second wind was considered in the Kansas State University program, but less so as the season progressed because it was determined not to have a significant influence on the well-trained runner.

Another recognized objective of training was the increase of arteriovenous oxygen difference. Costill related that the physiological capacity of the body to consume oxygen has depended, among other factors, upon cardiac output and arteriovenous difference. This difference referred to the oxygen saturation of the arterial blood being pumped from the heart as compared to that of the venous blood after it has served the needs of the body tissues. Montoye wrote of "evidence that the resting arterio-venous oxygen difference increases with training."²⁵ This greater arteriovenous difference was determined to be a

result of increased capillarization of the muscle fibers, augmented peripheral heart function, and increased efficiency of the heart.

To increase the size and strength of the athlete's heart has been a specific objective of the Kansas State University cross country program. It has been proven through research that continued, gradually increased stress on the cardiovascular system will cause cardiac hypertrophy.²⁶ Both cardiographic and x-ray shadow studies have supported this contention.²⁷ Costill related an unusual, but enlightening case in regard to hypertrophy of the heart:

Post-mortem examination of the distance runner's heart is seldom possible; however, findings in the case of Clarence DeMar, who competed in over 1000 long-distance races during his life, revealed a significantly enlarged heart. In 1958, DeMar was diagnosed as having peritoneal carcinomatosis, but he continued to train to within two weeks of his death. His heart weighed 340 grams (average male heart 300 grams). The left ventricular wall was 18 mm thick (average 10-12 mm).²⁸

Although this increase in heart size has been recognized as important, the real significance has been the resulting increase in efficiency.

Since the heart has been described as the pump of the entire cardiovascular system, it has been evaluated in terms of the amount of blood propelled by its pumping action. This cardiac output was determined to be dependent upon the rate and force of the heart beat.²⁹ Cardiac output was discussed in terms of minute-volume or stroke volume which meant the amount of blood put out by the heart per minute or per stroke respectively. Abrahams wrote the following in regard to the effect of physical work on cardiac output:

In an average healthy subject at rest, each ventricular contraction expels 100 millilitres ($3\frac{1}{2}$ ounces) of blood at each beat, which with a cardiac rate of 72 per minute means 7 litres ($1\frac{1}{2}$ gallons) - the 'minute-volume'. During extreme exertion the ventricular output at each contraction may be doubled and the

cardiac frequency rise to 160 a minute or even higher. The minute-volume thus increases to 37 litres (8 gallons).³⁰

In well conditioned runners the increased oxygen requirement of the contracting muscles during exertion has been answered by an increased flow of blood to the areas in need. This increase was accomplished by the greater stroke volume of the heart in these trained athletes.³¹ This increase in stroke volume has been coupled with the decrease of heart rate following training of the cardiovascular system.³² Steinhäus introduced the following in regard to this relationship:

Since the trained state is also accompanied by a distinctly slower pulse, it is obvious from the formula: minute-volume = rate X stroke-volume, that the stroke-volume is much larger in the athlete.³³

Therefore, the output of the heart has been established as a significant measurement of the efficiency of the entire cardiovascular system. Almost every function the oxygen transport system accomplished for the body was determined to be better or worse depending upon the amount of blood pumped.³⁴ The improvement of this efficiency has been a specific objective of the Kansas State University program.

Another consideration regarding cardiovascular improvement as an effect of training was augmented peripheral heart function of the exercising muscles. This function referred to the forcing back of more blood to the heart. The heart was found to cope with the stress of this increased venous return by increasing its rate and its stroke volume.³⁵ Therefore, it was felt that this increased peripheral action was a necessary stress in the conditioning of distance runners.

Related directly to this peripheral action was the importance of increased capillarization of the musculature. The supply of oxygen

to the muscles during exertion was determined to be dependent not only on the cardiac output, but also on the surface area of the capillaries through which the transported oxygen was moved into the muscle fibers.

Ward presented the following:

Each muscle receives blood through arteries which break up into profuse capillary networks in the connective tissue surrounding the individual muscle fibres. Under resting conditions most of these capillaries are closed but they open when the muscle becomes active. In the gracilis muscle of a dog, Martin found 1,050 open capillaries per square millimetre in the resting muscle and 2,010 open when the muscle was exercised. In a similar area there were 1,690 muscle fibres. Therefore, there is more than one open capillary per muscle fibre during exercise. Blood flow through muscles may be from four to nine times greater in exercise than in rest in a trained man and three to six times greater in a layman.³⁶

In addition, it was pointed out that training not only produced an increase in the number of capillaries, but also that the cross-connections between capillaries was improved. Consideration of the better oxygen exchange made possible by this increased capillarization has caused it to be one of the specific cardiovascular objectives of the Kansas State University program.

Primary Emphasis During Weeks One to Ten

With these objectives in mind, a training program was established for the 1970 Kansas State University cross country season. According to Gerschler, the two major methods of increasing endurance were overdistance running and interval training.³⁷ As Table I indicates, the Kansas State University program placed primary emphasis on overdistance work during the first ten weeks of practice. Progressively, more and more coaches are changing to a great volume of this type of training.

The information for Table I was compiled from the 1970 Kansas State University cross country program written by Coach DeLoss Dodds.

TABLE I

The 1970 Kansas State University Cross Country Program presented below illustrates the emphasis for each week, the mileage covered, and an explanation of the workouts.

WEEK	1st EMPHASIS	2nd EMPHASIS	TOTAL MILES	TOTAL OD MILES	EXPLANATION
July 6-12 13-19 20-26	OD*		60-80 70-90 80-100	60-80 70-90 80-100	Get these miles by running 10-12 miles a day or by running a hard 6-8 miles one day then an easy 14-15 miles the next and alternating this way
Aug. 27-2 3-9 10-16 17-23	OD OD OD OD		90-100 90-110 90-110 90-110	90-100 90-110 90-110 90-110	Same as July but up mileage by starting morning work-outs.
Sept. 31-6 7-13	OD OD		100-120 100-130	100-120 100-130	Report back to school. Continue to build mileage using the same method as in July and early Aug. Continue two a day work-outs for at least five days a week.
Sept. 14-20	OD	Interval	100-130	90-120	2/Int. W.O. 4 miles each. Separate by 2 days O.D. 6 miles O.D. prior to W.O.
21-27	OD	Interval	100-130	90-120	2/Int. W.O. 5 miles each. Separate by 2 days O.D. 6 miles O.D. prior to W.O.
Oct. 28-4	Interval	OD	100-130	90-120	2/Int. W.O. 6 miles each. Separate by 2 days O.D. 6 miles O.D. prior to W.O.
5-11	Interval	OD	100-130	85-115	2/Int. W.O. 6-7 miles each. Separate by 2 days O.D. 6 miles O.D. prior to W.O.

TABLE I (continued)

WEEK	1st EMPHASIS	2nd EMPHASIS	TOTAL MILES	TOTAL OD MILES	EXPLANATION
Oct. 12-18	Interval	OD	100-130	85-115	2/Int. W.O. 7 miles each. Separate by 2 days O.D. 6 miles O.D. prior to W.O.
Oct. 19-25	Interval	OD	100-130	85-115	2/Int. W.O. 7-8 miles each. Separate by 2 days O.D. 6 miles O.D. prior to W.O.
Nov. 26- 1	Interval	OD	100-130	85-115	2/Int. W.O. 8 miles each. Separate by 2 days O.D. 6 miles O.D. prior to W.O.
Nov. 2- 8	Interval	OD	40- 60	35- 55	1/Int. W.O. 4 miles 6 miles O.D. prior to Int. W.O. Big 8.
Nov. 9-15	Interval	OD	100-130	85-115	2/Int. W.O. 8 miles each. Separate by 2 days O.D. 6 miles O.D. prior to W.O.
Nov. 16-22	Interval	OD	60- 80	50- 70	2/Int. W.O. 4 miles each. Separate by 2 days O.D. 6 miles O.D. prior to W.O.

* Overdistance

Week, as a vertical column heading, indicates the particular period of days to which the information to the immediate right would pertain. The First Emphasis indicates which type of work would receive primary emphasis for that week, whether it be overdistance (OD), or interval training. The Second Emphasis column indicates which type of work would receive a secondary emphasis during that particular week. The Total Miles lists the total miles to be covered that week. The range of total miles was 40 to 130 miles. The Total OD Miles indicates the mileage to be covered specifically by overdistance training with a range of 35 to 130 miles. The column entitled Explanation gives a brief explanation of the week's practice format. For example, the explanation for the week of November 16-22 would read: Two interval (Int.) workouts (W.O.) of four miles each to be separated by two days of overdistance (OD). Six miles of overdistance (OD) would be run prior to each interval workout (W.O.).

Cooper explained how he felt about a program that did not emphasize overdistance:

I'm still mad at my college coach because he cut me back. I used to run long distances. I really enjoyed this in high school, running 10, 15, 20 miles. I won the state championship in the mile and didn't even have a coach. I learned myself by trial and error that this (long running) helped me.³⁸

Though some previous coaches have not understood the importance of overdistance, there have been many examples of successful distance runners that utilized this type of work. Cromwell supported this in the following statement:

Paavo Nurmi used to run back and forth to his place of work which was 5 miles from his home. Cunningham and San Romani covered long distance on foot in going to school.³⁹

Many influential running authorities have supported the value of an overdistance program. Lydiard, a vigorous advocate of this approach, wrote:

To acquire this necessary stamina, it is not easy, and many hours of running over distances is required to develop the organs and condition the body for the hard race ahead. Athletes I train do a great deal of long running.⁴⁰

Truex concurred with Lydiard when he wrote, "I think one of the most important things is to put on the mileage."⁴¹ Henderson, who has championed a training concept of long slow distance offered the following:

Nature, in all her wisdom, has provided us distance runners with a means to compensate for the speed she denied us. That is endurance. It's as changeable as basic speed is rigid. It's as long-lasting as sharpness is fickle and fleeting. Best of all, it's as safe and enjoyable in coming as speed training is difficult and rather dangerous. Endurance at its purest and best comes slowly and steadily and can climb to fantastic levels if approached just that way - slow and steadily. It's as simple as ambling down the road at a pace well within reach.⁴²

Physiologically, long distance training is believed to place the greatest stress on aerobic metabolism.⁴³ Ward pointed out that, "The most favorable stroke-volume occurs when the pulse-beat is approximately 130 to 150 per minute."⁴⁴ Maintenance of this pace was believed necessary in order to derive the desired effect on the cardiovascular system. This effect was presented as an increase in capillarization and an improvement in the overall efficiency of the heart.⁴⁵ In regard to the capillarization factor, Dunaway, et. al. wrote:

By running very long distances at slow speeds (10 to 15 miles at a pace of six to eight minutes per mile), a runner increases the number of capillaries in his muscle fibers, which improves the speed and effectiveness of the oxygen-exchange process. This kind of training can actually double the number of capillaries in each muscle fiber.⁴⁶

Thus it was concluded that overdistance training not only increased the capacity to move blood through the system, but also improved the ability to move oxygen directly to the muscle cells.

The utilization of overdistance as a base for other training and the application of the overload principle to the building of that base was an important consideration. "Lydiard feels that a sound foundation of conditioning must be laid down before any serious work can be done."⁴⁷ Stampfl concurred that, "Easy cross-country running is the ideal gentle means of breaking oneself into rigorous training."⁴⁸

Spendler introduced the following:

The pattern of all training is graduated according to severity. Thus easy cross country running which makes the least demand on the human nature comes first on the program.⁴⁹

With these concepts in mind the Kansas State University program prescribed gradually increasing the mileage to be covered strictly by overdistance for the first ten weeks. It was determined that both morning and afternoon workouts were needed to allow for a progressive increase in mileage significant enough to ready the runner for the introduction of more intense work. The progressive nature of this phase of the Kansas State University program is related in Table II.

Interval Training Emphasis

At approximately the eleventh week of training the Kansas State University program introduced interval training. The exact date of introduction for each runner was dependent upon the amount of base mileage that had been built up by that particular individual through overdistance work. If the runner had not achieved enough base, he was instructed to remain on the overdistance program until he was considered ready for the transition.

TABLE II

Kansas State University Progressive Overdistance Mileage
by Week*

Subject	Aug. 24-30	Aug. 31 - Sept. 6	Sept. 7-13
J.C.	93	110	119
J.G.	95	111	119
D.H.	84	103	104
R.H.	68	100	103
J.H.	109	117	118
F.R.	70	111	113
C.V.	66	75	82
J.N.	75	80	90

* This data was compiled from workout records of the Kansas State University Cross Country team. Each column indicates the total number of overdistance miles covered by the subject during the particular week of column heading. For example, subject J. C. progressed from ninety-three miles during the week of August 24-30, to one hundred and ten miles during the week of August 31 to September 6, and covered one hundred and nineteen miles during the week of September 7-13. The mileage range for all of the subjects was 70 to 119 miles. Subject J. H. ran 109 miles during the week of August 24-30 as compared to only 66 for subject C. V. The difference was due to the prior mileage bases already established by both runners.

Interval training has been termed the most scientific of the cross country training methods. Its use has grown considerably in the last two decades. Epskamp wrote that, "no training innovation in recent years has had as much impact on track as interval training."⁵⁰ This type of training became prominent after the coaching successes of the German coach, Dr. Woldemar Gerschler. The basic principles of interval training as presented by Gerschler were:

1. Physical exercise, everybody knows, increases the heart beat. Rest slows it down.
2. Repeated physical exercise - such as is found in training, diminishes, eventually, the number of beats for the same volume of blood for a given time.
3. The volume of blood in the body is constant for a given individual. Then, if the heart beats diminish for the same volume of blood, the quantity of blood pumped at each beat is increased. As a result, the heart itself has thus increased in volume.⁵¹

Working from these basic principles, Gerschler and a German cardiologist, Dr. Herbert Reindel, were able to establish what has been termed the Gerschler-Reindel Law. Sprecher presented the following explanation of this physiological concept:

After these 3,000 experiments had been carried out for 21 days, it appeared that the heart did not at any time surpass 180 beats per minute in the course of physical exercise - 180 beats represents a limit.

From this point (180 beats), the heart is permitted 1 minute, 30 seconds to return to 120 or 125 beats per minute; if it takes longer, it is because the effort demanded is (1) either too violent, or (2) too long.

In the second case, the distance to be run should be shortened. One minute, 30 seconds also represents a limit. When the pulse has returned to 120-125 beats per minute, the runner is able to - and ought to - begin running again, even if the heart took less than 1 minute, 30 seconds to recover.

In resume, what is most important is:

1. Bring the heart to 120 beats per minute by a preliminary warmup - not only by running on the track but also by exercise of all kinds - in order to begin the workout effectively.
2. From this point, the runner does a given distance - 100, 150, or 200 meters in a given time which will bring the heart up to about 170-180 beats per minute.
3. Soon afterward, the heart ought to take a maximum of 1 minute, 30 seconds to return to about 120 beats per minute. This time could be shortened however, but what is important is the return of the heart to 120-125 beats per minute. When this occurs, the runner should begin running again.⁵²

There were five variables to be considered in the formulation of interval workouts. Mollat classified these variables as distance, speed, repetition, interval, and action during recovery.⁵³ The term distance referred to the length of each run. The distance used in the early part of the Kansas State University interval training work was the quarter mile. This distance was chosen because it offered the proper stimulus for the heart without the utilization of an excessive tempo that would have been uncomplimentary to the premise of gradual intensification. The term speed simply referred to the rapidity of the run. Repetition pertained to number of exertions that would be used during the workout. The term interval meant the time elapsed between each run. More specifically, this principle of intervalization was presented as the "continuously changing rhythm between work and rest, designed to repeatedly subject the human organism to stress."⁵⁴ As previously mentioned, the interval is governed by the pulse rate. One hundred and eighty beats was used as a starting point for the interval since beyond that point the heart can neither fill nor empty completely and thus the desired stress is not presented.⁵⁵ At one hundred and twenty beats the heart has recovered to the point where it can cope with renewed stress.

If the interval lasted longer than ninety seconds there was found to be a pooling of the blood in the venous system and therefore less chance for optimum heart volume during the next exertion. The fifth variable pertained to any action the athlete executed during the interval of recovery between each run. Usually this action has involved walking or jogging. Down wrote:

Easy jogging, for example, will stimulate venous return by the "milking" or massaging effect of contraction muscles. On the other hand, if one merely stands still, the recovery process is liable to be only partially accomplished.⁵⁶

Physiologically, interval training has the desired cardiovascular effects of a greater efficiency of the heart through increased stroke volume and decreased pulse rate and a better utilization of oxygen through increased capillarization.⁵⁷

To accomplish these cardiovascular gains, it was felt that the interval training program needed to be progressive in nature.⁵⁸ The progression of the Kansas State University program is indicated in Tables I, III, and IV. Table IV also illustrates the pulse rate chart used to conduct an interval workout.

Overdistance running was continued through the weeks of interval training emphasis. Overdistance was considered as a necessary complement to interval work not only because of its previously mentioned values, but also because running overdistance allowed recovery from the more severe work of interval training. Thus interval workouts were separated by two days of overdistance. Interval sessions were also preceded by light overdistance to prepare the athlete's cardiovascular system.

TABLE III

Kansas State University Interval Training
Pulse Rate Average Sheet*

Subject	Sept. 14 20/440 @ 70-74 sec, 80 sec. interval	Sept. 22 24/440 @ 71-74 sec, 80 sec. interval	Sept. 28 28/440 @ 70-73 sec, 70 sec. interval	Average Pulse Reading
J. H.	70 182 112 71	48 163 115 69	49 177 128 69	Av. Drop Av. High Av. Low Av. Time
D. H.	60 180 120 71	58 164 107 71	44 173 129 72	Av. Drop Av. High Av. Low Av. Time
J. G.	67 190 123 71	60 171 111 70.9	47 176 129 73	Av. Drop Av. High Av. Low Av. Time
J. C.	55 184 129 71	40 163 123 70.5	42 173 131 71	Av. Drop Av. High Av. Low Av. Time

* This information was compiled from Kansas State University cross country workout data to illustrate the progressive nature of that phase of the training program. The subjects used were members of the Kansas State University cross country team. The data located immediately below the dates September 14, 22, and 28 regarded the specific interval training workout used for the corresponding day. For example, the workout for September 14 would read: twenty quarter miles at a pace of seventy to seventy-four seconds each, with an eighty second interval separating each effort. The last vertical column to the right related the average drop in pulse rate (range of 40 to 70 beats) during the

interval between each run, the average high pulse rate (range of 163 to 190 beats) immediately following each run, the average low pulse rate (range of 107 to 131 beats) at the conclusion of each rest interval, and the average time (range of 69 to 73 seconds) for all of the runs. The average readings of each subject were complimentary to the Gerschler-Reindel principle of a pulse rate goverance of approximately 180 to 120. For example, during the September 14 workout J. C. had an average high of 184 and the eighty second interval was sufficient to bring about an average low of 129.

TABLE IV

Kansas State University Interval Training
Pulse Sheet*

Workout 20/440 @ 70-74 sec., 80 sec. interval Date September 14

Name	Rp.	T.	1P	2P	Rp.	T.	1P	2P	Rp.	T.	1P	2P
J. C.	10	71	185	130	14	71	185	135	18	71	180	130
J. G.	10	71	190	125	14	71	205	125	18	71	190	125
D. H.	11	73	175	120	15	72	185	120	19	71	185	125
J. H.	12	71	185	120	16	70	180	110	20	75	180	115

Workout 24/440 @ 71-74 sec., 80 sec. interval Date September 22

Name	Rp.	T.	1P	2P	Rp.	T.	1P	2P	Rp.	T.	1P	2P
J. C.	11	72	170	120	14	70	170	100	17	71	175	110
J. G.	12	70	180	115	18	70	180	120	24	70	170	120
D. H.	12	70	160	110	18	70	175	110	24	71	170	100
J. H.	12	71	185	120	19	70	180	120	22	69	170	100

Workout 28/440 @ 70-73 sec., 70 sec. intervalDate September 28

Name	Rp.	T.	1P	2P	Rp.	T.	1P	2P	Rp.	T.	1P	2P
J. C.	13	71	180	140	16	72	170	130	23	71	175	130
J. G.	10	73	180	135	11	73	180	135	17	75	180	125
D. H.	11	72	175	130	18	72	175	125	27	69	175	130
J. H.	12	69	175	125	19	69	180	125	25	70	180	140

* This information was compiled from Kansas State University cross country workout data. Rp. (repetition) refers to the specific run which is being measured. The range of total repetitions is twenty to twenty-eight. T (time) lists the time of that particular run - range 69 to 75 seconds. 1P (first pulse) refers to the pulse rate taken immediately after that particular run - range 160 to 205 seconds. 2P (second pulse) pertains to the pulse rate taken just prior to the start of the next run - range 100 to 140 beats. Subject J. H., Kansas State University leading runner, was shown able to maintain a faster average pace for each run and yet have a heart rate recovery in the progressively prescribed interval.

SUMMARY

The present study was intended to emphasize the importance of cardiovascular training for cross country runners and to relate the principles that form the basis of this type of training for the Kansas State University cross country program.

The basic premises upon which the Kansas State University program was built included an understanding of adaptation to stress and an application of the overload principle so that the stresses presented would be gradually increased. These fundamental concepts have made the

program into a logical format which is recognized as successful. The specific cardiovascular training objectives included the increased efficiency of both the heart and the entire arteriovenous system. Objectives related directly to the heart included the increase of its size and strength and the increase of cardiac output. Emphasis was placed on improvement of the peripheral heart function through the increased capillarization which would also increase the arteriovenous difference. The increase of the runner's crest load was also discussed as an objective.

The first ten weeks of the Kansas State University program placed primary emphasis on overdistance conditioning. The cardiovascular effect of this training was an increase in capillarization along with a greater overall efficiency of the heart. The value of overdistance as a base for the more strenuous exertion of interval work was confirmed.

Beginning with approximately the eleventh week of practice, interval work was emphasized by the Kansas State University program. This type of training presented a greater stress to which the heart must adapt. The resulting benefit was a great improvement in heart efficiency as well as continued capillarization.

CONCLUSION

It was found that cardiovascular training was indeed an essential phase of any successful cross country program. It was also concluded by the author that the premises used as a basis for the Kansas State University program were substantiated and sound. The cardiovascular objectives of the program were correct according to the

literature reviewed. Finally, the cardiovascular phase of the 1970 Kansas State University Cross Country program was logical and substantiated according to the research that is now available.

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A STUDY OF THE CARDIOVASCULAR PHASE
OF THE 1970 KANSAS STATE UNIVERSITY
CROSS COUNTRY PROGRAM

by

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B. S., Kansas State University, 1966

AN ABSTRACT OF A MASTER'S REPORT

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The purpose of this problem was three-fold. The first purpose was to explain and emphasize the importance of cardiovascular training for cross country runners in general. The second purpose was to relate the principles governing the cardiovascular training of the Kansas State University cross country team. The third purpose was to theoretically evaluate the 1970 Kansas State University cross country program in regard to cardiovascular conditioning.

A thorough investigation of works by authorities in the field was executed to facilitate the explanation and evaluation of cardiovascular training. Working with the Kansas State University varsity cross country team was helpful in the formulation of both an explanation and evaluation of that specific program.

Cardiovascular training was found to have an extremely positive effect on the physical preparation of cross country runners. The competitive cross country race was explained to place a prolonged increase on the oxygen demands of the working muscles. Therefore, endurance capability can be enhanced only through the improvement of the oxygen transport or cardiovascular system.

The principles upon which the Kansas State University program was built included an understanding of adaptation to stress and an application of the overload principle so that the stresses would be gradually increased. These fundamental concepts have made the program into a logical format which has been recognized as successful. The specific cardiovascular training objectives included the increased efficiency of both the heart and the entire arteriovenous system. Objectives related directly to the heart included the increase of its size and strength

and the increase of cardiac output. Emphasis was placed on improvement of the peripheral heart function through the increased capillarization which would also increase the arteriovenous difference. The increase of the runner's crest load was also discussed as an objective.

The first ten weeks of the Kansas State University program placed primary emphasis on overdistance conditioning. The cardiovascular effect of this training was an increase in capillarization along with a greater overall efficiency of the heart. The value of overdistance as a base for the more strenuous exertion of interval work was confirmed.

Beginning with approximately the eleventh week of practice, interval work was emphasized by the Kansas State University program. This type of training presented a greater stress to which the heart must adapt. The resulting benefit was a great improvement in heart efficiency as well as continued capillarization.

It was found that cardiovascular training was indeed an essential phase of any successful cross country program. It was also concluded by the author that the premises used as a basis for the Kansas State University program were substantiated and sound. The cardiovascular objectives of the program were correct according to the literature reviewed. Finally, the cardiovascular phase of the 1970 Kansas State University Cross Country program was logical and substantiated according to the research that is now available.