A COMPARISON OF OVERDISTANCE INTERVAL TRAINING SYSTEMS AND SHORT DISTANCE INTERVAL TRAINING SYSTEMS IN HIGH SCHOOL DISTANCE RUNNERS

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by

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ABSTRACT

Title: A Comparison of Overdistance Interval Training Systems and Short Distance Interval Training Systems in High School Distance Runners

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Purpose of the Study

The purposes of this study were (1) to determine the effect of a short interval distance training system on high school runners, (2) to determine the effect of an overdistance interval training system on high school runners, (3) to determine if both methods of interval training were more effective in increasing performance on the post-test, and (4) to contribute some reliable information to distance coaches which they can use to develop training programs.

Statement of the Problem

The problem of this study was to collect data on the similarities and the differences of two methods of interval training used by adolescent high school distance runners. Specifically, the investigator determined, by use of the pre and post-test tools, if one group of runners demonstrates any significant gain or increase over another group of runners.

Statement of Hypothesis

There is no significant difference between an overdistance interval training system and a short distance interval training system for high school runners.

Procedures

A high school cross-country team was used in a pretest/post-test design. The team was divided into two groups by rank order, a short distance interval group and an overdistance interval group. A variation of Cooper's Twelve-Minute Run-Walk Test was used as the evaluative tool for assessing significant differences, if any. The *t*-test and the analysis of covariance were used in the statistical procedures.

Results

The results are as follows:

1. The overdistance group significantly improved its scores when comparing the pretest to the post-test.
2. The short distance group significantly improved its scores when comparing the pretest to the post-test.
3. The overdistance group significantly improved its resting pulse rate scores when pretest periods were compared to post-test periods.
4. The short distance group did not improve significantly its resting pulse rates when comparing pretest periods with post-test periods.
5. No significant statistical difference existed when pretest scores of both groups were compared with post-test scores of both groups.
6. No significant statistical difference existed when pretest resting pulse rates of both groups were compared with post-test resting pulse rates of both groups.

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Chapter I

INTRODUCTION

Running is one of the most primitive forms of athletic endeavor regarded as a sport and has been a popular form of competition from the earliest times. It occupied a prominent place in the ancient Olympic Games and has, since then, continued to grow in the number of competitors (34:II). Running provides a competitive situation which has spawned much public acceptance both in the United States and the world.

Over the past centuries many training systems have developed. Many people believe man is competitive by nature and, therefore, he has attempted to develop methods by which the athlete may train for competitive running most efficiently. Doherty (9:77-110) lists the major types of training systems as: (1) fartlek, (2) interval training, (3) The Oregon System of Training, and (4) The Lydiard Training System. Costill (6:11) also identifies methods of training similar to Doherty, namely, (1) Interval training, (2) Homer Fartlek, (3) Overdistance running and (4) Lydiard type.

Interval training has seemed to forge to the front as the most popular of the many training methods that can

be used by the runner. "Interval training is a system of repeated efforts in which a distance of measured length is run on a track at a timed pace alternately with measured recovery periods of low activity (9:87)." This type of system appears to have an advantage over other methods of training because of the number of stress factors and a greater workload in a given time that can be adjusted to meet the individual developmental needs of the runner. Also, if one applies the Gerschler-Reindel Law to interval training, there will be a scientific basis for determining the nature of the interval program and a tool for measuring the physiological development of the runner. The Gerschler-Reindel Law allows the pulse rate to return from 180 to 120 beats per minute before the next interval run (34:150).

In the last decade, interval training systems have been used quite extensively by many types of runners. Unfortunately, with the wide use of interval training systems, very little data has been documented about the young adolescent distance runner. Most of the information that has been gathered has developed from champions of national and world reknown caliber. Franz Stampfl expressed the present frustration about training techniques when he said:

> Our knowledge of training is still elementary, and a great deal of experimenting must continue for years to come. Mostly the experiments will be made by men of set purpose - pioneers who, dissatisfied by established practice, will strike out for themselves in search of some new formula to clip fractions of time from existing

> records. A few will succeed, most will fail but by virtue of challenging established methods all will have made some contributions to progress. (32:40)

THE PROBLEM

There is a considerable void in the types of interval training systems that have been developed for the average adolescent high school distance runner. Generally, interval training systems are considered to have five variables, (1) terrain, (2) distance, (3) number of runs, (4) pace, and (5) recovery (9:87). In this study the investigator tested different applications of some of these variables and attempted to fill some of the void of information about interval training for high school distance runners.

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The purposes of this study were (1) to determine the effect of a short interval distance training system on high

school runners, (2) to determine the effect of a over-distance interval training system on high school runners, (3) to determine if both methods of interval training were more effective in increasing performance on the post-test, and (4) to contribute some reliable information to distance coaches which they can use to develop training programs.

Statement of the Hypothesis

There is no significant difference between an overdistance interval training system and a short distance interval training system for high school runners.

Limitations

This investigation was limited to the number of boys that participate in cross-country in the grades nine through twelve at Wellington High School for the 1972 season. This study was also affected by the following factors over which the investigator had no control: (1) past participation of the athlete in a running program, (2) individual differences of athletic ability determined by chronological age and physiological development, (3) participants that moved, became ill or injured, and (4) participants that voluntarily withdrew from the cross-country program.

Delimitations

This study was bounded by the following: (1) only high school cross-country runners were used, (2) the participants were grouped as a result of a rank order

method, (3) only two types of interval training programs were used, a short distance and overdistance interval training system, and (4) interval training systems for both experimental groups were designed upon the need of each group and bounded by the limitations of the investigation.

DEFINITION OF TERMS USED

For the purpose of this study the following definition of terms were used:

Overdistance

Overdistance was defined as any distance in excess of 880 yards.

Interval Training

Interval training was defined as, a system of repeated efforts in which a distance of measured length was run on a track at a timed pace alternately with measured recovery periods of low activity (9:87).

Short Distance

Short distance was defined as any distance that was shorter than 440 yards.

High School

High School was defined as any student enrolled in grades nine through twelve and ages fourteen through eighteen.

Distance Runners

Distance runners were defined as any males participating in high school cross-country programs.

Pulse Rate

Pulse rate was defined as the number of times the heart or pulse beats during one minute.

Warm Up

Warm up was defined as the initial exercise used or a physical and mental preparation for strenuous exertion. Warm up exercise was usually a progressive pattern which involves jogging, striding, calisthenics, and acceleration running to sprint speed, and in between patterns of walking (34:256).

Warm Down

Warm down was defined as a slacking in exercise and intensity following severe exertion for the purpose of increasing the rate of return of the circulatory system and other bodily functions to a resting state (34:256).

Jogging

Jogging was defined as a form of slow easy running in which the steps are extremely short and the arms tend to hang for greater relaxation (34:258).

Recovery

Recovery was defined as a restitution, restoration or return to a relatively normal resting state following exercise (34:264).

Cross-Country

Cross-country was defined as running a distance not confined to a track. In the State of Kansas the competitive distance for scholastic running was two miles.

Chapter II

REVIEW OF RELATED LITERATURE

The review of related literature is divided into five main divisions. These divisions are: Historical Origin of Interval Training, Physiological Basis of Interval Training, Factors of Interval Training, Strengths and Weaknesses of Interval Training, and Summary and Conclusions. It is hoped that these divisions will simplify the review of the related material.

HISTORICAL ORIGIN OF INTERVAL TRAINING

Historically, the origin of interval training is difficult to determine. Epskamp (12:58) reported interval running was started by Woldemar Gerschler and Rudolph Harbig who set world's records in the 440 meter dash and the 800 meter run. Smit (34:180) credits Lauri Pikhala, Finnish coach, as the pioneer in the field. Pikhala in 1920 stressed the rhythm between work and rest in a method he called Tarrace Training. Ecker (11:16) writes that interval training originated and developed in Germany during the late 1930's. Doherty adds to the confusion about the origin of interval training by stating:

> No one person or country can be credited with the invention of interval training. Runners of the 1920's

> did "ins and outs" or took a series of "wind sprints," or did "repeated speed work." Like most systems, interval training evolved gradually over a period of ten years and more. (9:88-89)

Doherty (9:89-90) also reported that physiologist Dr. Heibert Reindell with Woldemar Gerschler are generally credited with developing and perfecting the system between 1935 and 1940 in their work with Rudolph Harbig. In July of 1939 Rudolph Harbig set a world record of 1:46.6 for the 800 meter run and less than one month later set his second world record of 46.0 for the 400 meter dash. Harbig's training diary contained not only the general over-all pattern but many of the variations of interval training. During World War II, Harbig was lost in combat, and no other man of his talent came under the direction of Gerschler and Reindell (9:91).

According to Nett (34:201-202), Professor Reindell realized the old concept of interval work did not coincide with this entirely new and different discovery, which he called "Interval Training," Reindell refers to interval work as concerned with training of the muscles and nerve apparatus, as compared to interval training, which affects principally the heart muscle with stimulus intervals.

Franz Stampfl identified interval running in 1955 as the following:

> A method of training involving continuous changes of pace over accurately measured and timed distance, a fast run being followed by a slow one. Thus ten laps of 440 yards interval running in 60 seconds per fast

> lap called for twenty 440 yard laps altogether, each fast 60 second lap being followed by a slow one. (32:46)

Epskamp's description of interval training is similar to that of Stampfl when he stated:

> Interval training is performed on a track with the runners running a set distance in a given time for a specific number of times. Each fast run is followed by a recovery jog without rest. Thus eight laps of 440 yard interval running at a speed of 65 seconds per 440 calls for a total of 16 laps. (12:58)

Fred Wilt gives a modern definition of interval training in How They Train, when he stated:

> Interval training is a method of conditioning runners which involves variable factors including the distance of training runs, the number of repetitions of the training distance, the speed of the training runs, the duration of recovery period after each training run and the type of activity (walking or jogging) during the recovery period after each training run. Briefly it involves repeatedly running a specific distance at a pre-determined speed, resting a specific period of time following each run. (33:2)

Gardner and Purdy stressed an additional factor involved with interval running, the importance of the heart rate during training. They describe this type of interval training in terms of heart rate response rather than running speed. Gardner and Purdy stated, "Interval training consists of repeated runs of sufficient speed to bring heart rate up to 180 per minute or more, each followed by a rest interval sufficiently long to allow the heart rate to fall to 120 beats per minute (14:58)."

The importance of heart rate is not revolutionary to the concepts of interval training. Dr. Gerschler theorized that the recovery period strengthened the heart as the pulse

rate was returning from 180 to 120 a minute. The recovery period could be a slow jog or a walk and after such a training period of twenty-one days, the heart volume can be increased by one-fifth (34:151).

As Ecker (11:16) noted, the system of interval training has undergone many changes since its origin, especially in the intensity of the work completed by the runner, but the basic principle behind it remains the same: repeated speed develops speed and endurance. Doherty (9:91) stated, "America heard nothing of interval training until after 1953."

PHYSIOLOGICAL BASIS OF INTERVAL TRAINING

Dr. Woldemar Gerschler has developed basic principles of physical exercise which form the foundation for interval training. They are (1) the heart rate increases with physical exercise and decreases with rest, (2) repeated physical exercise decreases the number of beats for the same volume of blood, (3) the volume of blood in the body was constant, then if the heart beat decreases for the same volume of blood the amount of blood pumped at each beat was increased in volume (34:15).

Gerschler and Reindell carried out 3000 experiments associated with the preceding basic principles and interval training. These experiments lasted for twenty-one days, and the heart rate did not surpass 180 beats per minute in the course of physical exercise--180 beats represented a limit.

From this limit of 180 beats, the heart was allowed one minute and thirty seconds to return to 120 to 125 beats per minute. It was concluded that if it took longer to return to the 120 level than the allotted one minute and thirty seconds it was because the effort demanded was (1) either too violent, or (2) too long (34:151).

Gerschler also pointed out that one minute and thirty seconds also represents a limit. When the pulse has returned to the 120 level, the runner ought to begin running again (34:151).

Costill (6:3) supports Gerschler when he wrote, "The key physiological component essential for success in distance running is a superior, well trained cardio-respiratory system (6:3)."

Nett stated, "Interval training is heart training. The creation of a beneficial beat volume in the interval produces the stimulus for heart enlargement (34:202)."

Shepard (30:119) wrote that interval training not only stimulates the heart but also develops one additional factor, oxygen debt. This oxygen debt produces lactate in the active muscles, and during the recovery periods it is rapidly oxidized as a result of short interval training. Shepard also stated, with prolonged interval training a huge oxygen debt is produced, and accumulates not only in the active muscle but in the circulatory system.

Rosandich maintained that for maximum development of the heart, the rate must reach 180 beats per minute. He

suggested 220 yards as the perfect training distance for interval training, and notes that the heart stretches in the first thirty seconds after running stops, not during the running period. The need for more oxygen to fill the oxygen debt that Shepard wrote about causes the heart to pump an increased amount of blood from the heart. This action of the heart causes the stretch in the heart, and the efficiency of the heart is increased the more this stretch can be repeated. This entire process causes the pulse rate to drop, and efficiency and conditioning are gained (27:54).

This theory of adaption of the heart during the rest interval is also found in the writings of Nett when he stated, "It appears, that the chief stimulus for adaption processes of the heart occurs not during the actual exertions but during the respective rest intervals (34:200)." Nett (34:200) went on to state that the rest interval or pause must not last long because there is a backing up of the blood from the arterial system into the venous system. With these conditions present, optimal increase in blood volume during and after the next physical exertion are no longer beneficial to the runner.

Nett (34:200) reported similar information regarding pulse rate that other writers have mentioned. He stated that the pulse rate at the end of the pause should be in the area of 120 to 140 beats per minute. During the run itself the pulse rate should be 150 to 180 beats per minute.

Mirwald (22:9) wrote that Carlson has established upper limits of pulse rates through observation and experimentation which are a little higher than previously mentioned rates. Carlson found that most people have a maximal pulse rate of 190 to 200 beats per minute. Carlson concludes that the most beneficial level of training is obtained when the pulse rate is fifteen to twenty beats below the maximal level. This fifteen to twenty beats below the maximal level would allow the heart to beat between 175 to 185 beats per minute.

Doherty (9:92) wrote that Dr. Reindell and Dr. Joseph Nocker favor a distance that will allow the pulse rate to drop from the maximum to about 120 to 140 per minute in a recovery interval of forty to ninety seconds. This distance would be as short as 120 yards and not to exceed 440 yards and would depend upon the pace. Doherty added that there is no one repeated distance in interval training that is ideal; each has its advantages and disadvantages.

Doherty states:

> Physiological research concludes that these work periods "must not exceed 30 seconds" and that exertions of more than 90 seconds duration are not successful. On the other hand, such research was concentrated upon heart-capillary effects and did not consider many factors of development, relaxation and willed control that are also operative. (9:93)

Doherty also stated that the research of Reindell confirms reports by Nett and others that the recovery

interval serves as a dual role of recovery and development:

> During the first 30 seconds or so following each fast run, the heart actually undergoes its greatest stress and, therefore, its greatest development. Maximum heart rates apparently do not increase with training. If greater blood volumes are to be achieved, it must be through an increase in the amount of blood ejected by each stroke. When the exertion of the run is too great and the heart rate reaches 180 and more, the heart can neither fill nor empty completely. When the rate is below 180, the massaging or "booster-pump" action of the muscles aids the normal means for returning venous blood to the heart. Thus it is "pressured" into a full expansion and still has time for a complete emptying. Such a stimulus for heart development is present during each interval between runs, up to about 20 times in a single workout. (9:94)

From the preceding Doherty stated:

> Reindell concluded that the most effective time for recovery development interval should be between 45 and 90 seconds. In a mature and well trained man, when the pulse rate fails to return to between 120-140 within about 90 seconds, he has had enough interval running for that day. (9:94)

Doherty (9:95) reported that the least effective activity during the recovery interval is to lie in a prone position. Doherty also reported that Gerschler found pulse rates returned to normal by this method about as rapidly as they did when walking or jogging. Doherty went on to state, "What will best aid recovery and development in terms of venous blood return to the heart we can assume that rhythmical and relaxed action is best (9:95)."

Gardner and Purdy (14:56-57) stated that there are two phases in recovery; a short term phase which lasts about twenty to ninety seconds after exertion at low levels of effort, and a long term phase which starts at the conclusion

of the short term phase at about the ninety second mark after the conclusion of exertion. According to Gardner and Purdy the long term phase of recovery may last three to five hours for the pulse rate to return to pre-exercise rest levels. The long term phase recovery may be an indicator of the total level of effort of the workout. A high pulse rate during this period of long term phase recovery may indicate the runner has had enough. This concept was also supported by Doherty, Reindell, Gerschler and others. Gardner and Purdy also stated, "The rest interval should be shorter, like 30 to 90 seconds for low levels of effort and longer, like 3 to 5 minutes for the higher levels of effort (14:56-57)."

Nett (34:183) reported that Hollmann's interpretation of the function of interval training are the result of the physiological factors involved. During exertion heart beat, stroke volume and ventilation are increased. During the recovery phase, the main part of recovery takes place one to two minutes after the start of recovery, and sixty to eighty percent of the recovery takes place according to the intensity and duration of the exertion. The higher the intensity, the longer the time period of the recovery. As a result of the recovery, the lactic acid level in the blood remains low. When the new exertion begins, fatigue will be minimal, and the runner will be able to master a large quantity of work in a relatively short time.

Nett also reported that Hollmann's main consideration when choosing the work load is based on the following, ". . . immediately at the conclusion of the effort, the pulse frequency must be approximately 160 p/m and the rest interval or pause must last until the pulse frequency is between 110 to 120 p/m (34:185)."

Doherty (9:96) wrote that Reindell and Gerschler theorized that during an extended period of training, the stress of each run should produce a pulse rate at the end of recovery of about 120 to 140 with a rest interval of about 90 seconds or less. This was, of course, for a well trained and mature runner.

Sportsman stated, "The Swedes repeat the distance as soon as the heart rate returns to 80. Most Americans repeat the distance at the end of three to five minutes time (31:60)."

Nett reported the results of Astrand, "Astrand found that interval training with longer periods of stress (3 minutes duration) will cause a better progress in endurance development than short periods (½ minute duration) (34:229)."

Nett also reports in another work:

> The greater the "stress-stimulus" on the musculature, the less the expansion stimulus on the heart muscle. In such a case the heart muscle reacts not with increased "beat volume" but rather with increase in frequency in the number of beats. (34:198)

Nett stated the results of research show, "Endurance performances, which exercise little growth stimulus on

skeletal muscles, do on the other hand lead to absolute and relative enlargement of the heart (34:198)." Costill stated, "One must conclude that the best single predictor of running success is the maximal oxygen uptake volume (Ml/Kg/min) (6:3-4)." Shepard wrote that, "Interval training increases maximum oxygen intake 16.1 percent as compared to 15.3 percent for continuous training and 13.2 percent for circuit training (30:119)." Nett stated that, "Recently made scientific experiments have shown that long distance interval training produces better results in terms of general endurance than short interval training (34:229)."

P. Sprecher wrote that Dr. Gerschler gives a summary about what is most important of the physiological aspects in interval training, they are as follows:

> 1. Bring the heart to 120 beats per minute by preliminary warmup of all kinds of exercise 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 afterwards, the heart ought to take a maximum of 1 minute, 30 seconds to return to about 120 beats per minute. When this occurs, the runner should begin running again. (34:151)

FACTORS OF INTERVAL TRAINING

Like the historical origin and the physiological aspects there seems to be diverse thought regarding the factors involved in interval training. Doherty suggests that there are five factors in interval training, but

mentions six in his book Modern Training for Running. They are:

1. Terrain, which is always a measured, flat running track.
2. A distance to be repeated.
3. The number of times it is run.
4. The pace at which it is run.
5. The recovery interval of relaxed jogging.

Other Factors

6. The degree of ease with which a given workout is accomplished. (34:87)

Cherry and Boehm reported four factors of interval training. They are "(1) the total distance covered per day, (2) the distance and number of intervals run, (3) the pace, (4) the rest or recovery periods (5:20)."

Nett stated that Hollmann developed three factors to be considered in interval training. They are "(1) the duration of work, (2) the duration of the recovery phase, (3) the work intensity (34:182)."

Ecker stated, concerning the factors in interval training, "The coach should never allow his athletes to work on more than one of the factors involved in interval training during any one workout (11:16)." Epskamp also noted that, "If an athlete changes two factors simultaneously and experiences problems in his training it becomes twice as difficult to localize the reason (12:60)."

Epskamp differed with Doherty's view on the terrain when he stated, "All interval training is done on the grass. Grass surfaces permit us to add more volume to the training, and decrease the number of individuals likely to sustain minor leg and foot injury (12:60)." Wilt gave a similar

idea when he stated, "Interval training might well be done off the track over unmarked surfaces without benefit of stop watch timing (34:259)."

In reference to the distance to be covered, Doherty stated, "There is no one repeated distance in interval training that meets all needs; each has a special value and special limitations (9:92)." Doherty went on to note:

> There is a tendency in the U.S. to use 440 yards as the best training distance. There is no magic in the exact distance of 440 yards. Its main virtue is that it is one half or 1/4 or 1/8 of the runners competitive distance. (9:92)

Wilt (35:11) wrote that the distance to be run should be based on the results of the research done by the Russians and the Germans. The results reveal that maximum efficiency in interval training will be attained from distances of 110 yards to 220 yards. It is not advised to run greater distances than 220 yards. It is recommended, instead, to increase the number of repetitions, within a narrow area of speed for greatest efficiency.

Rankin wrote, regarding the selected distance for interval training, "The distance covered should be twice the individual's racing distance (26:53)." Lewis also stated in regard to the distance to be run, "The important point is that repetition distance should always be a fraction of the whole so that the desired racing speed can be practiced (20:53)." O'Conner stated, "A high school cross-country rnnner should concentrate upon 880 intervals with some 440's and mile repetitions (25:30)."

Costill stated:

> Noon reported the effects of two interval training programs during a 12 week period. The training program consisted of (1) a short distance group which trained at distances ranging from 30 to 440 yards at a fast pace, and (2) a long distance group which trained at distances ranging from 880 yards to two miles, and on long steady runs from 3 to 15 miles. Both groups covered 23 to 45 miles per week. The findings indicated that training caused more rapid positive changes in electrocardiographic and blood tests results and in running time for 5000 meters. The overdistance training caused the same change but with few extreme results and at a slower. Noon concluded that both types of training should be employed in planning long range work schedules since there were positive physiological changes unique to both long and short distance training methods. (6:13)

Doherty wrote that distances can be grouped as to their main advantages, although this depends upon the number of runs and the pace. Doherty stated: "(1) Speed distances (100 yards-200 yards); (2) fast-pace distances (300 yards-800 yards); (3) competitive pace distances (400 yards-1 mile); and (4) slow steady pace distances (660 yards-1½ miles) (9:93)."

Sands (29:90-95) reported that in a research study the most employed interval training distances used by high school distance runners was 440 yards. Also the most frequently used method of training high school cross-country runners was the interval training system. Sands reported that the mean total mileage per interval workout produced 6.24 miles in the early season, 8.0 miles in the mid season, and 6.48 during the late season. Nett stated, "The short distance interval training is generally on the way out,

although, the long distance interval training continues to thrive as a method of developing general endurance (34:230)."

Costill noted research done at Ohio State University to determine the frequency of interval training to produce a difference in endurance:

> One group trained 4 times a week, on short distance, high number repetitions interval program, while the second group trained on a two day a week program of both short distance and long distance running. It was found that both groups improved in the areas of cardio-respiratory fitness and the biggest difference between groups was the recovery heart rates. The 4 day a week group showed greater improvement in this recovery heart rate over the two day a week program. Researchers concluded that short, repetitive running is necessary for maximum improvement of cardiorespiratory endurance; long, less frequent repeated running is less necessary than is short distance running. (6:16-17)

Costill wrote, "Overdistance training would assist the runner in adapting to long periods of exhaustive discomfort (6:17)." He went on to report that research done by McDavid stated, ". . . that when total work was held constant, interval training offered no better results for endurance than uninterrupted running (6:18)."

Doherty (9:97-98) suggested that the number of repetitions in interval training depends on the total mileage to be achieved and upon the intended value. It is agreed that mileage is the first thing to be considered in endurance training. Doherty wrote that Gerschler maintains that twenty repetitions of a single distance was enough to produce maximal development. It is also felt by Gerschler

that forty repetitions would work against the development of the runner.

Epskamp (12:62) gave two ways for determining the number of repetitions that should be used: (1) ask each runner how he feels, and observe the level of fatigue, (2) use body weight before and after practice, and check pulse rate at a constant time of day. Sands stated, "The number of repetitions employed in interval training was similar to the interval period in that, the number of repetitions seemed to be dependent upon the distance selected (29:90-95)."

In regard to the number of repetitions in starting an interval training program, Rankin stated:

> Since the body needs to make adjustments to the newly imposed stress, workout intensity should be kept low, thus allowing the body to repair quickly. During the early stages, it is advisable to run on Mondays, Wednesday, and Fridays. (26:53)

Another factor closely associated with the number of repetitions is the pace the runner chooses. Antone stated, "Interval training provides the perfect situation for learning pace (1:54)."

Doherty told of the importance of pace when he stated:

> The basic tenet of interval training: the pace at which training runs are made tends to be faster than that of competitive pace such faster pace puts on overload upon the system generally and, as with strength training, produces development beyond when would be possible by doing the action at pace, no matter how long. (10:30)

Doherty also supported the preceding tenet by stating:

> Scientific experimentation is a great variety of situation not related to running confirms the tenet that we learn the specific action-rate that we practice. Change the rate at which a skill is performed and you change the efficiency of performance. (10:31)

Wilt also agrees with Doherty when he stated, "Running these distances at slower speeds is alleged to produce slower general circulatory-respiratory development (35:11)." He also wrote, "We again see the wisdom of training to run fast, not slow, and the best way to learn to race fast is to practice fast (35:75)."

Costill noted the importance of training pace when he stated, "The most optimal training pace would be the slowest pace at which the maximum oxygen consumption can be attained (6:21)." He went on to note, that runners using interval training must run at a pace that will develop a heart rate that is the same as, or larger than, the critical threshold heart rate (6:19).

Recovery is an important factor in interval training. Stampfl noted:

> Rate of recovery is a reliable guide. There should be no hangover effects from the previous day's work. If there are, it is safe to assume that too much was attempted too soon, and some curtailment in the mileage or the number of repetitions runs should be made at once. (32:42)

Wilt made the following comment:

> No one knows one minute of walking usually results in as much or more recovery as two minutes of jogging,

> on the basis of pulse recovery. Since jogging requires more energy than walking and is physically more difficult, it is generally assumed that jogging has a more beneficial training effect. (34:44)

Wilt went on to state, "In the absence of proof to the contrary, jogging is generally recommended as the recovery action in interval training (34:44)."

Doherty concurred with Wilt when he wrote, ". . . jogging is the best possible method of making rapid recovery from fatigue as well as avoiding muscle stiffness or soreness (8:22)." Sands research revealed, "11 of 17 respondents selected walking as the type of rest interval utilized most (29:90-95)."

Doherty (9:94) tried to point out that recovery must also be based on the maturity of the runner. A young runner may need as much as ten to fifteen minutes while a mature runner may need only thirty seconds. The length of rest should be based on individual reactions to the training system, not on the reported practice of a champion.

Doherty also suggested that there is a certain degree of ease in an interval training system. He stated the following:

> One cannot be said to have mastered a given workout or task with relative ease. To do that workout again and again until one is certain of all mastery establishes a fixed base of accomplishment from which one can more safely and surely upward to the next base. (9:98)

Stampfl gives his ideas about an effective training system when he stated:

> Whoever the athlete and whatever his temperament, the only effective training schedule is that which

> concentrates on a gradual build up in the amount and intensity of training. Most athletes suffer from too little training. (32:38)

STRENGTHS AND WEAKNESSES OF INTERVAL TRAINING

Doherty (9:104-106) suggested that there are numerable weaknesses of the interval training system. First, the short duration of the run permits less adaption to the pains of fatigue. Second, the shortness of time in the training program can be deceiving and dangerous when attempting too much, too fast, too soon. Success in practice is no guarantee for success in a competitive situation. Third, running interval training workouts may become boring. Fourth, one of the greatest dangers of interval running, may be development of great interval runners without development of great competitive runners.

Boehm noted one of the dangers of interval training is ". . . the possibility of one of the runners becoming bored due to continuous repetition (3:23)." Boehm also stated that "Once a runner becomes bored his attitude toward running precludes his reaching full potential and has a negative effect on the entire team (3:23)."

Nett agreed with Doherty and Boehm but offers another alternative. Nett stated that:

> The weakness of interval training on the cinder track is its great monotony. For this reason alone one finds practically all the best distance runners doing supplemental work in the fields, meadows or woods over a relatively long distance at slow pace. (34:174)

The strengths of interval training are obvious. Marsh stated:

> There is little doubt, as we review the training programs of the outstanding coaches and runners, that interval training is at the heart of every successful training program. (21:52)

Dr. Gerschler stated the greatest strength is the physiological basis that provides a scientific check on the runner. Gerschler stated: ". . . the runner is thus constantly checked, thus avoiding possible errors in training because of excessive enthusiasm or an understandable euphoria, if one is too much taken up with the method (34:152)." Gerschler went on to state, "With cardiac observation on the one hand and natural qualities on the other, the German method is not only incontestable but even indispensable (34:152)."

Lewis stressed the cardiorespiratory strength of interval training when he stated, "By exercising the heart and the lungs at their upper levels of efficiency, the upper limits are slowly extended (20:55)." Cherry and Boehm cited the uniqueness of interval training when they state:

> Since a man's program is based upon previous performance, he commences at levels easily within his reach and, following the progression chart, gradually increases the difficulty of his workouts. (5:76)

Rosandich also stressed the physiological strength when he stated, "Interval training is the most scientific of the training methods. The coach has a controlled situation before him where the athlete is paced at all times (27:54)."

Stampfl concluded by stating:

> One of the main charms of interval running is its flexibility, since it can be adopted to the varying needs of all athletes at any stage of development. It induces speed and stamina, which together produces pace judgment and an all-round improvement in physical well-being. (32:47)

SUMMARY OF RELATED LITERATURE

In a summary of the review of related literature there seems to be considerable confusion as to the founder of interval training. Doherty (9:88-89) noted that no one person or country could be credited with the invention of interval training. But he went on to note that most writers attribute Dr. Herbert Reindell and Woldemar Gerschler with perfecting the system prior to World War II. Nett and others have categorized interval training in various ways, but all writers seem to have a great similarity to the work done by Reindell and Gerschler.

It also must be reported that interval training is based on scientific physiological principles, although many researchers feel differently about their exact nature. Most writers agree that interval training is directly related to the heart, the respiratory system and the interaction of these two. Many writers (34, 27, 29, 9, 14) feel the importance for establishing upper heart rate limits in regard to maximum physical exertion. It also appears that authorities in the field of interval training theorized that the amount of rest after an interval run has a direct

relationship with the decreasing pulse rate. If the physical exertion is too severe, the lowering pulse rate will not return to the appropriate level within the prescribed amount of allotted time. Therefore, the real scientific value of interval training is in this physiological check on the cardiorespiratory system.

There seems to be wide spread opinion regarding the factors involved in interval training. Doherty (34:87) suggests six factors, others (34, 5) suggest three and four respectively. The number of factors may vary, but most authorities revealed that the terrain, distance to be repeated, number of times it was run, the pace, and the recovery interval were the essential factors involved in interval training (34:87).

Perfection in any training system is impossible, but the strength and weakness become important factors when considering this type of training system. Researchers (27, 32) feel that flexibility and physiological checks by far out weigh its other weaknesses. Others stated (9:104-106) that boredom of interval repetition creates monotony in the training system. Also there may be development of great interval runners without development of great competitive runners.

CONCLUSION OF RELATED LITERATURE

The data that has been compiled in the field of interval training was the foundation for this investigation.

From the review of related literature, the following may be regarded as pertinent to interval training.

1. Dr. Herbert Reindell and Woldemar Gerschler are given credit for perfecting the system of interval training (9, 34).

2. An upper limit is represented by 180 heart beats per minute (34:151).

3. Allow the heart one minute and thirty seconds to return to 120 to 125 beats per minute (34:151).

4. If the heart takes longer than one minute and thirty seconds to return to the 120 level, it was because the effort demanded was (1) either too violent, or (2) too long (34:151).

5. The chief stimulus for the adaption processes of the heart occurs not during the actual exertions but during the respective rest intervals (34:200).

6. Intervals between runs should not exceed 20 times in a single workout (9:94).

7. Pulse rates return to normal about as rapidly when walking or jogging (9:95).

8. Best single predictor of running success is the maximal oxygen uptake volume (Ml/Kg/min) (6:3-4).

9. "Interval training increases maximum oxygen intake 16.1 percent as compared to 15.3 percent for continuous training and 13.2 percent for circuit training (30:119)."

10. "Recently made scientific experiments have shown that long distance interval training produces better results in terms of general endurance than short interval training (34:229)."

11. Never allow the athlete to work on more than one factor involved in interval training during any one workout (11:16).

12. "There is no one repeated distance in interval training that meets all needs; each has a special value and special limitations (9:92)."

13. Repetitive running is necessary for maximum improvement of cardiorespiratory endurance; long, less frequent repeated running is less necessary than is short distance running (6:16-17).

14. "Interval training provides the perfect situation for learning pace (1:54)."

Chapter III

RESEARCH PROCEDURES

This investigation was to collect information on the similarities and the differences of two methods of interval training used by high school distance runners. The research procedures used in the study were broken down into five main divisions. The initial four divisions include The Pre-Conditioning Periods, The Pretest, The Study and The Post-Test Phase. The last division is Data Analysis, which describes the statistical methods that were used in evaluating the data collected.

PRE-CONDITIONING PERIOD

Four weeks prior to the beginning of the investigation, a letter was sent encouraging prospective members of the high school cross-country team to take part in a pre-conditioning phase of the study. A copy of the letter sent will be found in the appendix A. This pre-conditioning period did include light exercise, stretching, and a program of progressive jogging for three times a week for the four week period. The light exercise period lasted about fifteen minutes, and the jogging started at five minute durations during the first week and increased five minutes for each of

the next three weeks. If some participants did not take part in the pre-conditioning period, the rank order method of grouping did take this into consideration. The rank order method did establish two groups of almost equal total pretest scores, although there was a considerable variation within each group to account for individual differences.

THE PRETEST

During the first meeting of the entire team, the first in a series of three pretests were administered. The participants were also instructed in how to take their own resting heart rate by placing their right hand over their heart and counting the number of beats in one minute. They were issued a four by six card to record their resting heart rates and were requested to turn these in to the researcher once a week. They were encouraged to take their resting rate when they awoke in the morning. A copy of one of these cards appears in the appendix B.

A variation of Cooper's Twelve-Minute Run-Walk Test was administered on a competitive basis as the pretest, a total of three times on three days in succession. Dr. Kenneth Cooper describes the Twelve-Minute Run-Walk Test in Aerobics, a copy of this test appears in appendix C.

The weather conditions during the latter part of August were very undesirable for running. Therefore, the first few practices, including the pretest were conducted in the early evening. The temperature during the pretest

ranged from the mid 70's to the low 80's, and no wind or rain existed during the pretest.

The test was conducted on an asphalt 440 yard track, and no participants wore spiked track shoes, all wore tennis shoes or running flats. All participants were encouraged to eat a light evening meal, and most did not eat until practice was concluded.

Before the start of the pretest, participants were encouraged to do stretching and very light jogging as a warm-up procedure. During the pretest, the participants were started and stopped by a thirty-two caliber starter's pistol. In starting they were randomly lined up across the track at approximately the fifty yard line. No staggers were used and no waterfall start was used. (A waterfall start is a curved line across the track, used in distance races to replace staggers.) The starting instructions were for each participant to try to go as fast as he could in the twelve minute period and do his best. The starting commands were, "Runners To Your Marks," then a short pause and the sound of the gun. There were no false starts during the pretest.

Once the gun had sounded, the researcher and the student manager each started a Hanhart split timer stop watch. This was done to get an accurate measurement of the elapsed time. If the researcher's watch did fail, then the student manager's watch would be used. At no time during

the pretest did the researcher have to employ the use of the second stop watch from the student manager.

The researcher and the student manager stationed themselves at the starting line. As the participants circled the track the researcher informed them of how much time had elapsed. The student manager kept a record of how many laps they had completed.

During the pretest there were a few boys that did not participate in the pretest because of various reasons. The major reason was that they did not have a physical examination signed by a medical doctor, and therefore could not participate until this was completed. These boys were used as spotters and stationed around the track. They were instructed to return the pretest participants to the exact spot when the final gun sounded. If there was a question of the exact spot the participant attained, usually the spotter's observation would be used.

Once the final gun had sounded the participants were instructed to sit down on the track, with the aid of the spotter, until an accurate measurement could be made of their distance. The measuring device was a measuring wheel that the researcher could push on the found in front of him as he walked. The measuring wheel measured to the nearest foot. The researcher with the aid of the student manager started at the starting line and proceded around the track in a counterclockwise direction. This was the same direction that the participants had run. When the

researcher and the student manager reached the first participant they recorded the number of laps the participant had run, plus the number of feet from the starting line. This procedure was completed for each participant. As the researcher recorded this information the participant was allowed to walk until the researcher completed all participants in the same manner.

This particular process was followed for the three pretest days. If for some reason a boy could not participate in the pretest three days in succession he was not included in the study.

The total distance each participant ran was recorded, and the mean average of these served as a foundation for the ranking of participants in order from highest to lowest. The mean average was used because it will account for superior and inferior performances by individuals. A copy of the pretest ranking of participants appears in the appendix D.

THE STUDY

Grouping was a result of the rank order established by the pretest. The boy that ranked the highest was placed in Group A, while the boy that ranked second highest was placed in Group B. This pattern of alternation did continue through the entire list of those who completed the pretest. Then a flip of the coin determined which group was the short distance interval group and the overdistance interval group.

The size of the sample included ten in one group and eight in the other. The unequalness developed because one subject dropped out of the study. The youngest members were freshmen in high school, and oldest were seniors. They were separated in the following manner: five freshmen, seven sophomores, three juniors, and three seniors.

The investigator, with the aid of the student manager, did keep a daily record of the training workouts for each group. A copy of examples of Interval Workouts will appear in appendix F. Also each participant was instructed in how to take his own pulse and asked to keep a weekly record of his resting pulse rates through the season. It was hoped that pretest resting pulse rates could be compared with post-test resting pulse rates.

The intensity of the investigation was developed around a three day a week interval training system. This three day a week program was followed as the basis of the training program.

The overdistance interval group ran distances of 880 yards, 3/4 miles, 1 miles, 1 1/4 miles, 1 1/2 miles, and 2 miles, plus any distance in excess of 880 yards. The short distance interval group ran distances of 110 yards, 220 yards, 330 yards, and any distance not to exceed 440 yards. Both groups ran the same relative work load by keeping the total time run in a given workout.

Runners in both groups were instructed to aim for the certain pace within their physical ability. A stop

watch was used at appropriate intervals of distance to give the runners some idea of their pace. If they were aiming for a five minute mile, their pace at the 440 yard mark should be in the area of 75 seconds, at the 880 yard mark around two minutes and thirty seconds and continue to carry this pace through the mile. During the rest interval the runners were instructed to take their own pulse rates. This was accomplished by the runner placing his right hand over his heart (34:181). When the researcher said, "Go" the participants would begin to count the number of heart beats. The researcher also started a stop watch when he said, "Go" and after fifteen seconds the researcher would say "Stop." At this point if the pulse rate was less than thirty beats in fifteen seconds, which would be less than 120 beats per minute, the runner would begin the next interval run. If the pulse rate was greater than thirty beats per fifteen seconds, the runner would constantly check with the researcher by the "Go" and "Stop" method mentioned previously until his heart rate came within the thirty beats in the fifteen second level (34:150).

A warm-up and warm-down period was used for both groups, these periods did include stretching, light exercise and jogging. On the days when interval training was not employed, both groups went on long overdistance runs from four to eight miles. A copy of the conditions appear in appendix E.

The duration of the study was eight weeks, which did not include the pre-conditioning period. There was only one training period per day that was supervised by the researcher. Once the weather cooled, practices were moved from the early evening to the late afternoon.

POST-TEST

The post-test was conducted in the same exact manner as the pretest with these differences. First, the post-test was conducted in the afternoon, while the pretest was conducted in the evening. Second, the weather conditions were a little different. The temperatures were in the low 50's and high 40's during the three post-test days, as compared to the pretest temperatures which were in the mid 70's to low 80's. On one of the days the wind blew gustily from the north. There was no rain during the post-test.

It should be reported that during the post-test there was a short warm-up period of light exercise and jogging. All subjects wore tennis shoes or running flats, and the post-test took place on the same running track as the pretest. All other pretest requirements or administration and measurement techniques were met in the post-test except those previously mentioned.

It was noted by the researcher through observation that during the post-test some participants in the study were very enthusiastic about their results on the post-test runs, whereas there were a few participants who were not

motivated to do their best on the post-test. The researcher also noted that this lack of motivation by a few was offset by the enthusiasm of the majority, and this seemed to appear in both groups.

DATA ANALYSIS

The data in this investigation was gathered to determine if there was a difference between the overdistance interval training group as compared to the short distance interval training group on the post-test as compared to the pretest.

Two statistical tools were used in order to determine the significance of the material gathered. The first was the t-test which examined the similarity of groups on the pretest and post-test scores. The second was the analysis of covariance which was used to examine the statistical difference between groups and within groups on the post-test as compared to the pretest. Both the t-test and the analysis of covariance were used on the pretest and post-test mean scores in addition to the mean resting pulse rate scores during the pre- and post-test periods.

t-test

In the consideration of the data it was necessary to determine the difference between the pretest scores and the post-test scores of each group at each particular level.

The next area of consideration was to decide the standard deviation of each group at each particular level between the pretest scores and the post-test scores. In order to reject or approve the null hypothesis at the .01 or .05 level of significance, it was essential to decide the degrees of freedom to be employed. The degrees of freedom for the t-test were calculated by N-1. The t-test was used to determine if there was a significant difference between the pretest and the post-test. The formula that was used to calculate the t-value was as follows (28:257):

$$t = \frac{\bar{X}_A - \bar{X}_B}{\frac{S^2_A}{n_A} + \frac{S^2_B}{n_B} - 2r\frac{S_A}{n_A}\frac{S_B}{n_B}}$$

Where,

$\bar{X}_A$ = mean of group on pretest

$\bar{X}_B$ = mean of group on post-test

s^2_A = variance for pretest measures

s^2_B = variance for post-test measures

s_A = standard deviation for pretest measures

s_B = standard deviation for post-test measures

n_A and n_B = number of subjects on pretest and post-test measures

r = Pearson's product moment coefficient of correlation

Analysis of Covariance

The analysis of covariance was one of the statistical methods that was used to determine if there was a significant difference between groups on the post-test as compared to the pretest. This test was the statistical tool to determine if the null hypothesis was accepted or rejected.

Analysis of covariance is developed around the concept of equal means. To test this concept of equal means, it is necessary to obtain adjusted sums of squares and adjusted mean squares for the pretest and the post-test scores. The adjusted total sum of squares may be determined from:

$$SS_{ty}^{1} = SS_{ty} - \frac{(SP_t)^2}{SS_{wx}}$$

where SS_{ty} is the total sum of squares for Y (28:257).

Correspondingly, the adjusted sum of squares within groups may be calculated from:

$$SS_{wy}^{1} = SS_{wy} - \frac{(SP_w)^2}{SS_{wx}}$$

where SS_{wy} is the sum of squares within groups for Y (28:257).

Conclusively, the adjusted sum of squares between groups may be determined as a remainder (28:257).

$$SS_{by}^{1} = SS_{ty} - SS_{wy}$$

A similar rationale for analysis of covariance can be found in simple analysis of variance when the number of

degrees of freedom for the adjusted sum of squares between groups equals the number of groups minus one (k-1). Nevertheless, one degree of freedom is not retained by imposing the limitation that the deviation be computed from the common within groups regression line, and the number of degrees of freedom for the adjusted sum of squares within groups is (N-k-1) and for the adjusted total sum of squares is (N-2). The adjusted mean squares within and between are obtained by dividing the sum of squares by their particular degrees of freedom. The test of the hypothesis of equal means is acquired from (28:257):

$$F = \frac{MS_{by}}{MS_{bw}}, \text{ with df} = (k-1), (N-k), (N-k-1).$$

Chapter IV

ANALYSIS OF DATA

The main purpose of this study was to investigate interval training methods. It was an intent of this study to determine if some of the lack of accurate factual information in the area of interval training could be rectified by undertaking an empirical study of such training. This chapter contains the following areas in regard to the analysis of data. First, the response analysis will discuss how population and sampling were handled during the statistical analysis of data. Second, the statistical analysis will describe how the raw data was compiled to obtain meaningful results. And third, a short summary of material that appears in the chapter will be included.

RESPONSE ANALYSIS

The subjects for this investigation were selected from those members of a high school cross-country team that took the pretest. As was mentioned in Chapter III, there were a total of nineteen participants which contained ten subjects in the short distance classification and nine individuals in the overdistance classification. During the

investigation one of the subjects in the overdistance group voluntarily withdrew from the investigation. Before completion of the study, one subject in the short distance group was ill during the second and third post-test administration. As a result of this illness the pretest and post-test scores of this individual were not included in the final study. Therefore, the groups upon completion of the study had nine subjects in the short distance classification and eight subjects in the overdistance classification. Some of the data on the pretest and post-test resting pulse rates were incomplete. The investigator only used those subjects that furnished complete data in this phase of the study.

STATISTICAL ANALYSIS

In determining if there is a significant difference between short distance interval training and overdistance interval training among high school distance runners, it was necessary to analyze two factors. These two factors, distance and resting pulse rate, were used to determine if there was a significant difference between pretest and post-test scores. The distance factor was the increase or decrease in distance covered on a variation of Cooper's Twelve-Minute Run-Walk Test. In this test the individual mean scores of the pretest groups will be compared to the individual mean scores of the post-test group. The pulse factor will be the increase or decrease in resting pulse

rate during the pretest period as compared to the post-test period.

A t-test was used to decide if there was a significant difference between the pretest and the post-test scores in the overdistance group.

In Table 1, t-Test for Overdistance Group on Pretest and Post-Test Scores, a mean value of 2870.40 was obtained with a standard deviation of 127.26 on the pretest. On the post-test a mean value of 3179.19 was calculated with a standard deviation of 223.94. There were a total of eight subjects in this overdistance group.

Table 1

t-Test for the Overdistance Group on Pretest and Post-Test

Group	Number	Standard Deviation	Mean	Mean Difference	Degrees of Freedom	r	t
Pretest	8	127.26	2870.40	-308.79	7	.43	-4.0054*
Post-Test	8	223.94	3179.19				

*Significant at .01 level

A t-value was calculated by the formula found in Chapter III and a -4.0054 was obtained for this overdistance group. A t-table was used at seven degrees of freedom to determine the critical region. A t-value of $\pm$ 3.499 was needed to reject the null hypothesis at the .01 level of

significance. Since the obtained value of -4.0054 fell within the critical region the null hypothesis was rejected in this particular aspect of the investigation. The sample significantly improved their scores on the post-test as compared to the pretest. A correlation of .43 was determined between the pretest and the post-test and a mean difference of -308.79 was obtained.

In Table 2, t-Test for the Short Distance Group on the Pretest and Post-Test, a mean value of 2845.1 was obtained with a standard deviation of 218.02 on the pretest. A total of nine participants were in the short distance group. On the post-test a mean value of 3175.8 was found with a standard deviation of 122.74.

Table 2

t-Test for the Short Distance Group on the Pretest and Post-Test

Group	Number	Standard Deviation	Mean	Mean Difference	Degrees of Freedom	r	t
Pretest	9	218.02	2845.1	-330.7	8	.15	-4.0041*
Post-Test	9	122.74	3175.8				

*Significant at .01 level

A t-value was determined by the same manner as the t-value for Table 1 was calculated. A t-value of -4.0041 was obtained for the short distance group. The t-table was

used at eight degrees of freedom to decide the critical region. A t-value of ± 3.355 was needed to reject the null hypothesis at the .01 level of significance. Since the obtained value of -4.0041 fell within the critical region the null hypothesis was rejected. This was the similar to the overdistance group in Table 1. The mean difference was -330.7 which indicated that the short distance group improved their scores on the post-test as compared to the pretest. A correlation of .15 was determined between the pretest and the post-test which was a very weak correlation.

The t-test was also calculated for the resting pulse rate in the overdistance and the short distance groups.

In Table 3, a t-Test for Resting Pulse Rates in the Overdistance Group, a pretest mean value was obtained of 71.2 with a standard deviation of 3.39. On the post-test a mean value was found of 62.3 with a standard deviation of 5.38. In this group there was a total of six subjects.

Table 3

t-Test for Resting Pulse Rates in the Overdistance Group

Group	Number	Standard Deviation	Mean	Mean Difference	Degrees of Freedom	r	t
Pretest	6	3.39	71.2	8.8	5	.72	5.297*
Post-Test	6	5.38	62.3				

*Significant at .01 level

A t-value of 5.297 was obtained for the resting pulse rates in the overdistance group. The t-table was used at five degrees of freedom to decide the critical region. A t-value of $\pm$ 4.032 was needed to reject the null hypothesis at the .01 level. Since the value of 5.29 fell within the critical region the null hypothesis was rejected as significant at this level. The correlation of .72 was found between the pretest and the post-test scores with a mean difference of 8.8

In Table 4, a t-Test for Resting Pulse Rates in the Short Distance Group, on the pretest a mean value was found of 67.3 with a standard deviation 10.14. On the post-test a mean value of 58.9 was found with a standard deviation of 7.28. In this group there were a total of five subjects.

Table 4

t-Test for Resting Pulse Rates in the Short Distance Group

Group	Number	Standard Deviation	Mean	Mean Difference	Degrees of Freedom	r	t
Pretest	5	10.14	67.3	10.4	4	.75	3.412*
Post-Test	5	7.28	58.9				

*Significant at .01 level

In Table 4 a t-value of 3.412 was found for resting pulse rates in the short distance group. The t-table was

used at four degrees of freedom to determine the critical region. A t-value of $\pm$ 4.604 was needed to reject the null hypothesis at the .01 level. Since the value of 3.412 fell within the critical region the null hypothesis was accepted as significant at this level. The short distance group had a correlation of .75 with a mean difference of 10.4.

In determining if there was a significant difference between short distance interval training and overdistance interval training, it was determined to study the effect of more than two conditions at one time was warranted. Analysis of covariance allows a comparison of the mean scores between groups and within groups to take place at the same relative time.

Analysis of covariance was calculated for the distance factor and the resting pulse rate factor. In Table 5, the distance factor was determined and in Table 6, the resting pulse rate factor.

In Table 5, the sum of squares for the pretest scores between groups was 2678.9. The sum of squares for the post-test scores between groups was 48.2. The sum of products between groups was 358.1. The degrees of freedom at this level was 1.

Within the groups the sum of squares for the pretest scores was 555671. The sum of squares within the groups on the post-test scores was 532357.0. The sum of products within groups was 132168.4. The degrees of freedom within the group was 15.

The total sum of squares for the pretest scores was 558349.9. The total sum of squares for the post-test scores was 532405.2. The total sum of products was 132526.5. The total degrees of freedom was 16.

Table 5

Analysis of Covariance of Pre and Post-Test Scores

Source	df	SS_x	SP	SS_y	df^1	SS_y^1	MS_y^1
Between	1	2678.9	358.1	48.2	1	-122.38	-122.38
Within	15	555671.0	132168.4	532357.0	14	500920.3	35780.0
Total	16	558349.9	132526.5	532405.2	15	500797.9	-------

In an analysis of Table 5, the adjusted sum of squares between groups for the post-test scores was -122.38. The adjusted mean squares between groups for the post-test was -122.38. The adjusted degrees of freedom at this level was 1.

The adjusted scores within groups was 500920.3 for the adjusted sum of squares. The adjusted mean squares of the post-test scores was 35780.0. The adjusted degrees of freedom at this level was 14.

The total adjusted sum of squares was 500797.9, and the total adjusted degrees of freedom at this level was 15.

An F-value was computed by the formula for analysis of covariance and an obtained F-ratio of -0.00034 was attained. The F-Table was used at the one and the fourteen

level of degrees of freedom to determine the critical region. An F-value of $\pm$ 4.60 at this level was needed to be significant at the .05 level of significance. Therefore, the obtained F-value of -0.0034 was not significant at the appropriate level of significance as determined by the degrees of freedom. This supported the null hypothesis and the null hypothesis was accepted as the most tenable.

In Table 6, Analysis of Covariance of Resting Pulse Rates During Pretest and Post-Test Period, the sum of the squares for the pretest scores between groups was 40.13. On the post-test the sum of squares for between groups was 30.72. The sum of products between groups was 35.15. The degrees of freedom at this level was 1.

The sum of squares within the groups for the pretest was 584.3. The sum of squares within the groups on the post-test was 439.0. The sum of products within the groups was 358.59. The degrees of freedom within the group was 9.

The total sum of squares for the pretest scores was 624.4. The total sum of squares for the post-test scores was 469.72. The total sum of products was 393.75. The total degrees of freedom was 10.

Table 6

Analysis of Covariance of Resting Pulse Rates During the Pretest and Post-Test Periods

Source	df	SS_x	SP	SS_y	df^1	SS_y^1	MS_y^1
Between	1	40.13	35.15	30.72	1	-14.55	-14.55
Within	9	584.3	358.59	439.0	8	218.93	27.37
Total	10	624.4	393.75	469.72	9	204.38	------

In an analysis of Table 6 the adjusted sum of squares between groups for the post-test scores was -14.55. The adjusted mean squares between groups for the post-test was -14.55. The adjusted degrees of freedom at this level was 1.

The adjusted scores within groups for the post-test was 218.93 for the adjusted sum of squares. The adjusted mean squares of the post-test scores within groups was 27.37. The adjusted degrees of freedom at this level was 8.

The total adjusted sum of squares was 204.38, and the total adjusted degrees of freedom at this level was 9.

An F-value was computed by the formula for analysis of covariance, an obtained F-ratio of -0.53 was calculated. The F-Table was employed at the one and the eight level of degrees of freedom to decide the critical region. An F-value of $\pm$ 5.32 at this level was needed to be significant at the .05 level of significance. Therefore, the obtained

F-value of -0.52 fell within the critical region and was not significant at the appropriate level of significance as decided by the degrees of freedom. This supported the null hypothesis and the null hypothesis was accepted as most defendable.

In summary of this chapter the following information was found to exist. When a t-test was calculated for the short and overdistance group both results fell outside the critical region for the null hypothesis and the null hypothesis was rejected. When the t-test was determined for resting pulse rates the null hypothesis was rejected for the overdistance group and accepted for the short distance group. When analysis of covariance was calculated for the pretest and post-test scores and resting pulse rate scores, the null hypothesis was accepted.

Chapter V

SUMMARY, FINDINGS, CONCLUSIONS, DISCUSSION AND RECOMMENDATIONS

This investigation was developed around the concept that there might be a way of training the high school distance runner in the most practical application of interval training. Training for distance running at any level, especially high school, has been such an individual endeavor that a concrete basis for training has been practically impossible to determine. Too many times training has been a hit or miss thing that leads to success or failure of the distance runner. This investigation tried to use one of the most popular present day training systems, interval training, and to develop some scientific information regarding the success or failure of adolescent high school distance runners using this system. The investigator hopes this information will be valuable to high school distance coaches, high school distance runners, and anyone else interested in the field of training distance runners.

SUMMARY

The initial phase of the investigation occurred when a letter was sent to prospective members of a high school

cross-country team encouraging them to take part in a four week pre-conditioning program of stretching exercises and light progressive jogging. A copy of this letter may be found in the appendix A.

After this four week pre-conditioning period and at the first meeting of the entire team, a variation of Cooper's Twelve-Minute Run-Walk Test was administered on a competitive basis. Cooper's Twelve-Minute Run-Walk Test served as the pretest and was administered on three days in succession. A total of nineteen subjects took the pretest. At the conclusion of the pretest the subjects were ranked by mean score on the pretest from highest to lowest. This rank order method was used to obtain two relatively equal groups, although considerable variation occurred within each group. A flip of a coin determined which group would be the short distance interval group and which group would be the overdistance interval group. The short distance group would run distances shorter than 880 yards in interval training and the overdistance group would run distances in excess of 880 yards in interval training.

The training period lasted eight weeks with approximately three interval training sessions per week. The participants were instructed how to take their own resting pulse rates, and were requested by the researcher to keep a record of these during the investigation. These resting pulse rates were taken during the early morning prior to the

start of school. Pulse rates were also used to determine the relative work load, after an interval run, if the subject's pulse was down to thirty beats in fifteen seconds, or 120 beats per minute, it was determined that the subject should begin to run another interval run. In this manner, total time of the training session determined the relative work load for both groups in each training session.

After eight weeks of the training period a variation of Cooper's Twelve-Minute Run-Walk Test was administered as the post-test. This was done on three days in succession. The mean post-test scores, mean pretest scores, and the resting pulse rates during the pretest and post-test periods were analyzed by the t-test and the analysis of covariance.

FINDINGS

This study was based on the null hypothesis that there would be no significant difference between the short distance and the overdistance group on the post-test as compared to the pretest in an interval training session. Within the limitations of this study, the following information was discovered by the researcher.

1. Both the short distance and overdistance group improved on a variation of Cooper's Twelve-Minute Run-Walk Test when comparing their pretest to their post-test scores.

2. Both the short distance and overdistance group decreased their resting pulse rate when comparing the pretest period with the post-test period.

3. A t-test for the overdistance group on the pretest and the post-test rejected the null hypothesis that there would be no significant difference within the overdistance group on the post-test as compared to the pretest.

4. A t-test for the short distance group on the pretest and post-test indicated a rejection of the null hypothesis that there would be no significant difference within the short distance group on the post-test as compared to the pretest.

5. A t-test for the resting pulse rates in the overdistance group rejected the null hypothesis that there would be no significant difference within the overdistance group.

6. A t-test for the resting pulse rate in the short distance group accepted the null hypothesis that there would be no significant difference within the short distance group.

7. Analysis of covariance of the pretest and post-test scores of the short and overdistance interval group supported the null hypothesis that there would be no significant difference between the short distance interval group and the overdistance interval group on the post-test as compared to the pretest.

8. Analysis of covariance of resting pulse rates of the short distance interval group and the overdistance interval group supported the null hypothesis which stated that there would be no significant difference between either group on the post-test as compared to the pretest.

CONCLUSION

This investigation was developed around the concept that there might be a more efficient way to train adolescent distance runners through the use of interval training. The following information may be concluded in regard to this investigation within the limitations described by the researcher.

1. The overdistance group significantly improved its scores when comparing the pretest to the post-test.

2. The short distance group significantly improved its scores when comparing the pretest to the post-test.

3. The overdistance group significantly improved its resting pulse rate scores when pretest periods were compared to post-test periods.

4. The short distance group did not improve significantly its resting pulse rates when comparing pretest periods with post-test periods.

5. No significant statistical difference existed when pretest scores of both groups were compared with post-test scores of both groups.

6. No significant statistical difference existed when pretest resting pulse rates of both groups were compared with post-test resting pulse rates of both groups.

DISCUSSION

In retrospect the researcher would like to emphasize a few areas of this investigation that might be of interest to individuals involved in some aspect of distance running. It seems that coaches and runners are searching for a system of training that surpasses all others. A system when used properly would allow the athlete to reach his full potential in the area of distance running. Unfortunately there is no miracle or magic system that will make champions out of individuals who do not have the characteristics necessary to perform at the championship level. Also there is no substitute for hard work and dedication in any training system.

Assuming that the runner will put forth the necessary effort, interval training can offer the runner and the coach considerable benefits. Interval training allows a constant check on the fatigue level of the runner by checking pulse rates and the rate of pulse return to the rest level. With this one factor the coach may individualize each runner's workout because he is aware when the runner has had enough training for an individual training session. Other training systems do not have the large number of interval rest periods between runs.

The initial hypothesis of this study stated that there would be no significant difference between an over-distance interval training system and a short distance interval training system for high school runners. Although both groups improved on the post-test as compared to the pretest, neither group improved significantly over the other. This was revealed by the analysis of covariance. When examining resting pulse rates by the same statistical method, the same results were found. Both groups lowered their pulse rates, but no statistical difference existed between groups. Interval training brings the desired effects upon the runners, but personal preference may determine which type of interval system was chosen. Since there was no difference in either short or overdistance systems, this in itself may be a valuable piece of information.

Through the duration of the investigation, the subjects showed interest in the study. The subjects were aware of the importance of the resting pulse rate, and as the study came to a conclusion, they realized that their pulse rates did decrease. Also most subjects were eager to see their post-test results and wanted to see how much they improved over the pretest. The reason the researcher mentioned the interest by the subjects was because the researcher felt that the subjects were highly motivated when they knew they were a part of an important scientific investigation. An interesting method to motivate runners

might be to inform them that they are part of an investigation, explain the scientific implications, and see if this helps motivate the subjects to run.

RECOMMENDATIONS

As a result of the findings in this investigation there is certain information that might be useful to future investigators in this field of interval training and related areas. These recommendations are offered as directional guidelines so that future researchers might consider them before undertaking a similar study. These recommendations are as follows:

1. Decrease the number of three pretest and three post-test to two pretest and two post-test. There seemed to be an increasing amount of monotony or boredom by the third pretest and post-test.

2. Administer the study to non-athletes in physical education classes.

3. Administer the study to well trained athletes, such as college athletes.

4. Increase the number of weeks of the investigation.

5. Have larger groups in the study.

6. Use mechanical devices to measure resting pulse rate.

7. Administer the study to adolescent girls.

8. Administer the study to adult joggers.

9. Add a third group that would be a control group.

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APPENDIXES

APPENDIX A

LETTER TO PROSPECTIVE CROSS-COUNTRY RUNNERS TO TAKE PART IN PRE-CONDITIONING PROGRAM

July, 1972

Dear Prospective Cross-Country Runner:

Last spring you indicated that you would or might be interested in cross-country. This is your pre-conditioning program. It has been designed for three days a week. This will prepare you for the fall cross-country season. The program will take you about 20 to 35 minutes to complete (per day), and I hope you follow it to the best of your ability. Here are a few points to remember:

1. Never work out in the heat of the day--either in the early morning or early evening.
2. Stay <u>On</u> the grass and <u>Off</u> the roads.
3. Try to have a day of rest between each workout--Mon., Wed., Fri., or Tue., Thurs., Sat.

Pre Season Conditioning Program--3 Days a Week.

Warm-up - (total time--15 minutes)

1. Stretching--do the following to get your muscles loose.
   A. Arm Swings - 1 to 2 minutes.
   B. Toe touch - 1 to 2 minutes.
   C. Hip rotations - 1 to 2 minutes.

2. Set-ups, try to start with 10 and increase this by 2 each time you work out.
   A. Bent legs
   B. Straight leg

3. Push-ups, try to start with 10 and increase this by 1 or 2 each time you work out.

Jogging--3 Days per Week.

1. Week of July 24 to July 29--5 minutes easy jog (3 days per week)
2. Week of July 31 to Aug. 5--10 minutes easy jog (3 days per week)
3. Week of Aug. 7 to Aug. 12--15 minutes easy jog (3 days per week)
4. Week of Aug. 14 to Aug. 17--20 minutes easy jog (3 days per week)

I hope to see you at our first practice on August 17. If you have any questions, please contact me. I will be out of town from July 7 until July 23.

Sincerely,

(Signed)
Coach Wallace

APPENDIX B

EXAMPLE OF CARD USED TO RECORD SUBJECTS RESTING PULSE RATE

Name_____ Group_____
Date_____

Resting Pulse Rate --- Count the number of times your pulse beats in 15 seconds and multiply by 4 and record. Hand in this card at the end of each week.

Mon.	Tues.	Wed.	Thurs.	Fri.

APPENDIX C

COPY OF DR. KENNETH COOPER'S TWELVE-MINUTE RUN-WALK TEST, TAKEN FROM AEROBICS, NEW YORK: M. EVANS AND CO., p. 54, 1968

"Start out running, but if your breath gets short, walk for a while until it comes back, then run some more." "Keep going for the full 12 minutes."

"When you've checked the distance you've covered in 12 minutes, you can find your oxygen consumption on the chart and determine your Physical Fitness Category."

FITNESS CATEGORY	DISTANCE COVERED	OXYGEN CONSUMPTION
I. Very poor	Less than 1.0 mile	28.0 ml's or less
II. Poor	1.0 to 1.24 miles	28.1 to 34 ml's
III. Fair	1.25 to 1.49 miles	34.1 to 42 ml's
IV. Good	1.50 to 1.74 miles	42.1 to 52 ml's
V. Excellent	1.75 miles or more	52.1 ml's or more

APPENDIX D

PRETEST RANKING OF PARTICIPANTS

BY MEAN AVERAGE

RANK	MEMBERS OF OVERDISTANCE GROUP	MEAN AVERAGE
2.	Coates	3014.2
4.	Sawyer	2987.2
6.	Russell	2966.5
8.	Bruster	2957.6
10.	Washburn	2857.9
12.	Mouser	2789.8
14.	Kabureck	2766.5
16.	Nuss	2623.5
18.	Hockman	2489.3

RANK	MEMBERS OF SHORT DISTANCE GROUP	MEAN AVERAGE
1.	Bradley	3176.2
3.	Jaurequi	3000.5
5.	Parrish	2972.7
7.	Hall	2964.7
9.	Durant	2874.6
11.	Glenn	2853.7
13.	Watts	2774.3
15.	Clewell	2720.0
17.	Norris	2599.8
19.	McCloud	2468.3

APPENDIX E

SAMPLES OF CONDITIONS IN OVERDISTANCE RUNS FOR BOTH THE OVERDISTANCE INTERVAL GROUP AND SHORT DISTANCE INTERVAL GROUP

	COURSE	SURFACE	TERRAIN	DISTANCE
1.	Lake	Sand, Gravel	Mostly flat, few hills	6 miles
2.	School	Grass, Paved Roads	Flat	4 miles
3.	Golf	Grass, Few Roads	Flat to rolling	6 miles
4.	Elevator	Hard Roads	Rolling	7 miles
5.	Hill	Sand Road	Hilly	6 miles

APPENDIX F

EXAMPLES OF WORKOUTS FOR BOTH INTERVAL GROUPS

September 22, 1972

SHORT DISTANCE

1. Warm-up
   1 mile jog,
   total time; 10 min.
2. 10 x 440
   in pace, jog between,
   total time; 45 min.
3. Warm down
   1 mile jog,
   total time; 10 min.

Total time of entire workout,
65 minutes

OVERDISTANCE

1. Warm-up
   1 mile jog,
   total time; 10 min.
2. 5 x 880
   in pace, jog between,
   total time; 45 min.
3. Warm down
   1 mile jog,
   total time; 10 min.

Total time of entire workout,
65 minutes

September 27, 1972

SHORT DISTANCE

1. Warm-up
   1 mile jog,
   total time; 10 min.
2. 2 sets of 6 x 440
   walk between,
   78 to 95 pace
3. 4 x 110
   #2 and #3
   total time; 55 min.
4. Warm down
   1½ miles,
   total time; 20 min.

Total time of entire workout,
90 minutes

OVERDISTANCE

1. Warm-up
   1 mile jog,
   total time; 10 min.
2. 2 x 1 mile
   5 min. 30 sec. to
   6 min. pace
3. 3 x 880
   2 min. 40 sec. to
   3 min. pace
   #2 and #3
   total time; 55 min.
4. Warm down
   1½ miles,
   total time; 20 min.

Total time of entire workout,
90 minutes

October 10, 1972

SHORT DISTANCE

1. Warm-up
   1¼ miles,
   total time; 20 min.
2. 8 x 440
   jog and walk between
   pace
3. 10 x 110
   on grass, #2 and #3
   total time; 40 min.
4. Warm down
   1¼ miles,
   total time; 10 min.

Total time of entire workout, 70 minutes

OVERDISTANCE

1. Warm-up
   1¼ miles,
   total time; 20 min
2. 3 x 880
   2 min. 30 sec. to
   2 min. 45 sec. pace
3. 1 x 1 mile
   no time, #2 and #3
   total time; 40 min.
4. Warm down
   1¼ miles,
   total time; 10 min.

Total time of entire workout, 70 minutes