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The Relationship of Training Methods Between NCAA Division I Cross-Country Runners with 10,000 Meter Performance

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THE RELATIONSHIP OF TRAINING METHODS BETWEEN NCAA DIVISION I CROSS-COUNTRY RUNNERS WITH 10,000 METER PERFORMANCE

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THESIS ACCEPTANCE

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Abstract

The scientific relationship between 10,000 meter performance and training methods of distance runners remains incompletely understood. Researchers such as Slovic (1977) and Pollock (1978) have attempted to study the relationship between training practices of distance runners with the use of surveys. However, these studies did not analyze the significance of various types of training regimens available. The purpose of this study was to evaluate the training methods of NCAA Division I runners and 10,000 meter performance. Fourteen Division I qualifying teams of the NCAA Division I national cross-country meet and 16 randomly chosen non-qualifying teams were recruited through the mail and direct contact. The respondents completed a survey which evaluated the training methods of the respective teams during the transition phase, competition phase, and peaking period which encompassed seven months of training.

In the transition phase the non-qualifying teams ran significantly farther ($p<0.05$) on their long runs than the qualifying teams. The qualifying teams ran more miles during the competition phase than the non-qualifiers ($p<0.05$). No significant differences ($p>0.05$) differences were noted between the qualifying and non-qualifying teams during the peaking period.

No significant differences ($p>0.05$) were noted between the lower seven and top seven qualifying teams during the transition phase. However, during the competition phase the lower seven teams used intervals, fartleks, and repetitions more frequently ($p<0.05$) than the top seven qualifiers. Fartlek training during the peaking period was used more more often ($p<0.05$) for the top seven teams than the lower seven qualifying teams.

A Pearson correlation was performed to find correlations between final team time in the 10,000 meter run and various training indices obtained from the survey. Based on the results from this study, it was concluded that tempos, repetitions, intervals, and fartlek training during the transition phase were significantly ($p<0.05$) and positively related to team 10,000 meter performance. Interval training and fartlek during the competition phase were significantly ($p<0.05$) and positively related to team 10,000 meter performance. Tempo training during the peaking

period was significantly ($p<0.05$) and negatively related to team 10,000 meter performance.

The training variables were further correlated with team rank at the Division I national cross-country meet. Assessment of success based on order provided further insight on the training requisites for ultimate performance. Teams that ranked lower at the national cross-country meet practiced twice a day more often, and used fartlek training more frequently during the transition phase. For the competition phase, lower ranked teams used interval training and fartlek more often. Higher ranked teams used interval training more often during the peaking phase.

From this study's findings several recommendations were made concerning future research. Future studies should attempt to analyze differences that may exist between American and international training methods. A comparison of the training methods of the various collegiate divisions is needed to determine if similar training methods exist. Further research is needed on repetition, tempo, fartlek, and hill training to determine the physiological benefits that may be gained by using these training methods to peak an athlete. Further long term studies of the training of distance runners are needed.

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CHAPTER I

INTRODUCTION

Factors such as biomechanics, energy utilization, body composition, nutrition, and running philosophy have been associated with distance running success. From ancient Greece to modern times, athletes have had the desire to run faster and farther. As individuals began to improve their athletic talents, they have become enthusiastic to utilize information that would optimize their performance. Practicing has always been stated as the catalyst which improves a runner. However, knowing how to practice has been the essential key in developing success. Vigil (1995) stated " the fundamental condition of the body cannot change overnight, but it can be changed over a period of months and years of training by an intelligent and planned employment of all that is locked up in one's personality". With increased international competition in distance running, the challenge has focused on running better and smarter. In the 1920's, observers hid in trees and observed the training methods of the 10,000 meter Olympic champion Paavo Nurmi, in hope of discovering the secrets of his success (Karikoski, 1984). The training methods used by elite athletes throughout the years have influenced the training pattern of many athletes and coaches.

In 1964, interest in distance running in the United States was intensified by the efforts of Billy Mills, who became the first American to win the 10,000 meters at the Olympics. Since that time, research has attempted to identify the principles of successful distance running. Past research has validated the training procedures for lactate threshold, economy, glycolytic capacity, speed training, training volume, VO2 max, and tapering as separate variables (Martin & Coe, 1991). In 1977, Pollock provided valuable information on the energy output, biomechanics, body composition, nutritional status, and psychological factors of several elite athletes. Pollock utilized not only various laboratory procedures to gain details of the make-up of elite distance runners, but also a survey concerning the training habits of the athletes. The study was composed of 12, 10,000 meter distance runners, and eight marathoners. On average, the runners ran approximately 84 miles per week and had an overlap of training techniques. The

10,000 meter runners did more high intensity interval training than the marathon runners. At the conclusion of the study, the researcher held a race in attempt to assess the relationship between training methods with a survey. However, nine of the participants did not run due to prior race obligations or injury. The lack of participation in the race lessened the value of the research, so no findings were published. The lack of participants in Pollock's study emphasizes the difficulty in obtaining meaningful data on elite athletes. Elite athletes will often not complete a race-like simulation due to lack of monetary incentive or they may want to avoid an injury that may hamper further performances.

In 1978 Slovic attempted to examine the training methods of distance runners and their performance in a marathon. Slovic used a survey to assess the basic features of a runner's training program which had been associated with distance running performance. The survey of the runner's training habits included daily, weekly, and monthly mileage; length and frequency of ultralong runs; and days trained per week. Slovic used correlation and multiple regression analysis to indicate a systematic relationship between training and performance in the marathon. The results of the study indicated that the faster runners had run considerably more total miles than the slower runners, and that slower runners had their maximum-mileage week closer to the marathon. However, Slovic neglected to realize that many distance runners do not rely merely on mileage for success. Rather they utilize multiple forms of training methods to reach a peak performance.

With the emergence of the Mexican and Eastern and Northern African distance runners, American athletes have been less successful in international competition. It was almost 30 years ago that Kip Keino set the stage for East African runners by winning the 1500 meters at the Mexico City Olympic games. Since then, races from 1500 to 10,000 meters have been dominated by successful Kenyan runners. Scientists and athletes have researched the Kenyan lifestyle, diet, and altitude training. However, they have not been able to attribute the Kenyan success to any of these factors. The American 10,000 meter record by Mark Nenow is now 22 years old. This seemingly untouchable record is currently 36 seconds slower than the current world record. Evaluating the top 10 fastest American males indicates that 8 of the top 10 male runners ran their fastest race before 1987. Refer to Table I for a listing of the top 10 fastest American 10,000 meter runners (Anderson, 1996).

Table I. The Top Ten American 10,000 meter performances

Name	Time	Year
Mark Nenow	27:20.56	1986
Alberto Salazar	27:25.61	1982
Craig Virgin	27:29.16	1980
Todd Williams	27:31.34	1995
Bruce Bickford	27:37.17	1985
Ed Eyestone	27:41.05	1985
Steve Prefontaine	27:43.60	1974
Paul Cummings	27:43.70	1984
Steve Plascencia	27:45.20	1990
Frank Shorter	27:45.91	1975

Evaluating the top ten Kenyan runners in 10,000 meters exemplifies the American distance runners' inability to compete at the international level. Four out of the top ten fastest Kenyans ran their personal best within the last year. The oldest mark on the Kenyan's all-time list is only 5 years old. There has not been an American distance runner who has ever run under 27:20. However all the Kenyan runner's have run under 27:20 with two seconds or more to spare. Refer to Table II for a listing of the top ten fastest Kenyan 10,000 meter runners (Anderson, 1996). Many researchers are aware of the decline of American distance running and have unsuccessfully attempted to correlate the training methods of distance runners to their performance at an elite level.

Table II. Top Ten Kenyan 10,000 meter performances

Name	Time	Year
William Sigei	26:52.53	1994
Yobes Ondieki	26:58.38	1993
Ismael Kirui	27:06.59	1995
Richard Chelimo	27:07.91	1993
Josphat Machuka	27:10.34	1995
John Ngugi	27:11.62	1991
Paul Tergat	27:14.08	1995
William Kiptum	27:17.20	1994
Shem Kororia	27:18.02	1995
Moses Tanui	27:18.32	1993

With the determination and success of such athletes as Todd Williams and Bob Kennedy to catch-up with the world class competition, it is evident that the talent for winning at the international level is available in the United States. With communication and understanding of proper training methods, coaches and athletes can focus on the training tools to produce success. The few surveys that have studied distance running success have concentrated on the volume of miles run prior to competition (Slovic, 1977). The surveys have neglected to evaluate periodization, which is an important part of coaching and training (Freeman, 1989). Periodization includes not only changes in volume for competition preparation, but also various types of speed workouts. Exercise physiologists have identified the physiological benefits of speed workouts (Knuttgen, Nordesjo, Ollander & Saltin, 1973; Fox, Bartels, Billings, O'Brien, Bason & Mason, 1975)), but have not analyzed their synergistic effect with other training methods. With little scientific research on the periodization of distance runners, it appears there is a need for such a study. Therefore, the purpose of this study was to evaluate the training methods of elite distance runners in relationship to running performance for 10,000 meters.

CHAPTER II
THE PROBLEM

Purpose of the Study

The purpose of this study was to examine the relationship between training methods of National Collegiate Athletic Association (NCAA) Division I collegiate teams, and 10,000 meter run performance at the national cross-country championship.

Hypotheses

1. Each training variable assessed (i.e., total miles per week, longest run per week, tempo running, short easy running, repetition workouts, interval training, hill training, fartlek training, cross training, drills, weight training, rest and practicing twice a day) will be significantly related to the average 10,000 meter team performance.
2. Significant training differences exist between the top 7 qualifying teams compared to the lower 7 qualifying teams.
3. Significant training differences exist between the 14 national qualifying teams and 16 randomly selected non-national qualifying teams.
3. The use of various training methods can be used to predict the mean team 10,000 meter finishing time.
4. The frequency of each variable assessed (i.e., total miles per week, longest run per week, tempo running, short easy running, repetition workouts, interval training, hill training, fartlek training, cross-training, drills, weight training, rest and practicing twice a day) will be significantly related to the rank of of the teams participating in the National Division I Cross-Country 10,000 meter race.

Delimitations

Division I cross-country female runners compete at the 5,000 meter distance, while male competitors race at the 10,000 meter distance. Since the study was designed to assess the performance of 10,000 meter runners it was limited to male runners. The the competitors of the national meet will be composed of 22 teams (seven-man teams). Surveys were sent to the coaching staff of the prospective national qualifiers and non-qualifiers from the eight districts. Qualifiers consisted of the top two teams from each district race, and one additional team from districts two, three, and four. Three additional at-large teams were selected to qualify for the national meet. Criteria for being selected as an at-large team was based on the team's finish at the district meet, previous results of head-to-head competition between teams being considered, number of wins against teams already qualified for the national meet, and individuals on the team who are likely to score highly at nationals. Sixteen non-national championship qualifiers were randomly chosen to respond to the survey.

Limitations

The image of research by many elite athletes has been considered an invasive measure on their privacy. Consequently, some coaches may not wish to reveal their coaching methods. Some coaching philosophies approach the cross-country season as a method to build a mileage base in their athletes for preparation for the outdoor track season. Therefore, the athletes in this situation may not truly be in their peak performance. The national meet was a measure of performance of one competition. An individual may be injured or not mentally focused on the race which may have led to a poor performance. A poor performance by one individual may have drastically affected the team mean time.

A program may be successful due to the talent that the coach recruited and may not be due to the training methods of the team members. This can be a limitation because no matter how the runners are trained they may still be successful because of their genetic background.

Surveys are an ex post facto design because much of the training was accomplished before the top teams and individuals were selected for national competition. Since the data was collected "after the fact", the study relied heavily on the training logs of coaches and runners. Therefore, the inadequate documentation of training procedures was a limitation of the survey.

The survey instrument itself was a limitation based on its length. In order to extract training data, many detailed questions needed to be asked. A lack of returned surveys left gaps in the data collected. Further limitations in the survey resulted from the multiple interpretations of training terminology that may have lead to an inaccurate documentation on the survey.

The survey was designed to indicate correlations that may exist in the training methods and success in distance running. Correlations examined the common and specific variance of the survey results and not the cause and effect for success. Therefore the use of correlation was a limitation because it is only the initial stage of examining the actual cause-effect relationship of training procedures and success in distance running.

Definition of Terms

For clarity, the following terms are defined:

Cross training - A training session using an alternative mode of activity to running (e.g., cycling, swimming, etc.).

Drills - Supplementary training methods such as plyometrics, form drills, medicine ball drills, etc.

Fartlek - Swedish word which means "speed play". Fartleks are done at various intensities and lengths with mixed periods of hard running with easy running.

Hill training- Repeats at 85 to 90 percent effort on a graded hill for 30 seconds to 5 minutes, with a recovery jog back down the hill. Hill training is utilized to develop strength and power in the runner's stride.

Interval training- Repeated bouts of hard running at an intensity close to or faster than a runner's race pace followed by a recovery period lasting no longer than the time of hard running.

Repetition Running- Repeated bouts of hard running (400 meters or more) that are run faster than a current 10,000 meter race pace. The recovery period consists of 2 to 5 minutes of complete rest. Repetition training differs from interval training in that it has a more complete recovery than interval training.

Rest - Avoidance of running, weight lifting, jumping, cross training, and other forms of moderate or vigorous physical activities.

Repetitions - series of runs that are above 400 meters and are run faster than a current 10,000 meter race pace. The recovery period consist of two to five minutes of complete rest. Repetitions are designed to improve form, efficiency, and tolerance to fatigue.

Tempo runs- Distance run where the pace is 20 to 30 seconds slower than a runner's current 10,000 meter race pace. Purpose is to raise the lactate threshold of the runner

Significance of the Study

Attempting to analyze the world's best athletes cannot be done due to lack of funding and difficulty convincing the athletes to peak for one specific meet. However the pool for prospective elite athletes does exist in the United States. Many of the top American and international prospective runners compete and train at the NCAA Division I Level. Majority of these teams are consistently training in an attempt to compete for a national cross-country championship. These teams can readily be recruited to complete a survey on their training methods which can be compared with their performances at the national cross-country meet. Utilizing this pool of athletes may help us to understand the training requisites for success when competing at 10,000 meters. Furthermore, there has been little scientific research of the training methods of elite college distance runners.

Much of the current research is limited to a specific period of time, usually lasting 8 to 18 weeks, where the research team attempts to quantify a specific variable of the training performance of distance runners. Researchers have largely ignored that distance runners don't just train for 8 to 18 weeks, but rather over a period of months and years to reach a peak performance. Researchers have neglected to analyze the process of periodization of elite distance runners. Therefore, a knowledge of the scientific relationship between training practices and 10,000 meter performance remains incomplete.

Many critics of American distance running have blamed performances at the elite level on the American lifestyle, lack of discipline, and coaching. However, a better understanding of the relationship between training methods and performance may improve the efforts of American distance runners. Therefore, with the upsurge of interest in competing at the world class level in distance running, it is apparent that this survey may be valuable.

Chapter III
Review of Literature

Preparation for success as a quality distance runner takes many physiological and psychological steps. Willa Foster once stated that quality is never an accident; it is always the result of sincere effort, intelligent direction, and skillful execution (Vigil, 1996). There is no doubt that hard work is the most successful tool in meeting the true potential of a distance runner. Each individual has his or her own personal characteristics which enable him or her to improve and succeed in meeting his or her goals. Coaches have always been able to produce successful athletes by sharing experiences and feelings on training and racing tactics. The training work load must be as close as possible to the athlete's ability for success to occur. If the work load is too low, the athlete may not succeed and become frustrated; if the work load is too high, injury may occur. Coaches and athletes are always searching for a better training system for distance runners. In 1968, the first booklet on the "American System" of training was developed and adopted by many coaches and athletes striving to succeed at the international level (Freeman, 1989). The booklet advocated utilizing many interval-oriented training systems in attempt to peak the athlete for a particular event.

Periodization is a method of training development and tactics which has become the most successful method for organizing a planned training program for the distance runner (Freeman, 1989). The ultimate goal of a periodization training program is to increase the functional capacity of the musculoskeletal, circulatory and pulmonary systems of the body. From a biochemical perspective, these systems are the mediators of the use of oxygen to provide fuel breakdown and of the removal of carbon dioxide byproducts when ATP is formed. During a distance running event, the body may exchange oxygen at a rate twenty times greater than the resting state to meet the demands placed on the system (Martin, 1991). The capacity of these systems can be measured in a laboratory setting to predict the performance capabilities of the athlete. A lack of proper scientific understanding of these predictor variables can lead to improper periodization techniques for developing a successful distance runner.

There have been no drastic changes in the approach to training distance runners over the past few years. The small changes that have occurred result from the efforts of exercise physiologists in an attempt to explain and refine certain approaches to distance training that have been universally accepted. The following sections will attempt to identify the physiological components for determining successful distance running and the principles of training distance runners.

Predictor Variables

Why did Jim Ryan run a 3:51 mile and an 8:25 two mile with a VO_2 max of 81.0 ml/kg/min while Don Lash "only" ran a 4:07 mile and an 8:58 two-mile with a VO_2 max of 81.4 ml/kg/min (Daniels, 1976)? Questions like this have been established by exercise physiologists in an attempt to determine what physiological characteristics establish a successful distance runner. Certainly, improvements in facilities, communication, and understanding of the training principles and methods have helped to improve the performance of distance runners. Astrand and Rodahl (1977) listed energy output, neuromuscular function, and psychological factors as the major influences in performance. Brouda (1974) listed similar characteristics to improved performance which included strength, neuromuscular coordination, mechanical efficiency, maximal oxygen uptake, cardiac output, ventilation, blood lactate levels and anaerobic capacity. Daniels (1974) stated that the degree of improvement in these determinants is dependent on the degree of training. Distance training attempts to improve pulmonary ventilation, cardiac output, stroke volume, heart rate, oxygen carrying capacity of the blood, and oxygen utilization by the working tissues (Daniels, 1974).

Research on distance training has established that there is a close relationship between VO_2 max and performance of endurance runners (Costill, Thomason & Roberts, 1973; Costill, 1976; Hickson, Bomze & Holloszy, 1977). Costill, Thomason and Roberts (1973) stated that a high correlation ($r = -.91$) existed between VO_2 max and distance running performance for 16 highly trained distance runners. Frederick (1973) claimed that the size of a runner's maximal oxygen consumption (VO_2 max) is not the difference among trained elite athletes. Rather he believed the difference was due to the ability to sustain a high percentage of the runner's VO_2 max for prolonged periods. Athletes with the same ability to transport oxygen to the tissues may differ in the ability of the metabolic machinery of the cells to use oxygen available and sustain that level for long periods. Based on these principles, Bauerman (1991) stated that VO_2 max has a genetic limit, but the ability to sustain a running pace at a percent of an individual's VO_2 max is just as important as having a large VO_2 max.

Daniels (1974) indicated that further metabolic variations exist beyond levels of oxygen consumption in performance of elite distance runners. Daniels evaluated the performance of 24 Olympic distance runners who showed little variation in VO_2 max. Completion of the study indicated that a high VO_2 max is a requirement for success in distance running along with an elevated lactate threshold. Farrell, Wilmore, Coyle, Billing and Costill (1979) believed that the accumulation of lactate in the blood at different running velocities is the determinant that separates distance runners with similar maximal oxygen consumption. Costill, Thomason and Roberts (1973) found a high correlation ($r=.91$) between lactate accumulation and distance running performance. Farrell et al. (1979) demonstrated that experienced distance runners can utilize 70 percent of their VO_2 max before lactate begins to accumulate in the blood. Hickson, Hagberg, Ehsani and Holloszy (1981) indicated that significant ($p<0.01$)decreases in blood lactate occur after 3 weeks of training. Hickson et al. stated that participants changed there lactate levels from 11.5 $\pm$ 1.1 mM to 7.0 $\pm$ 0.8 mM. Thorland et al. (1973) concluded that the lactate threshold accounted for 71 percent of the variance in successful distance running performance. Thorland et al. also found that the onset of blood lactate is also closely related to the percent of slow twitch fibers of the runner. Costill (1967) indicated that a significant relationship exists between VO_2 max and the percent of slow twitch fibers in successful distance runners.

Further determination of the relationship of physiological variables was determined by Costill (1967). Based on his research on cross country runners, Costill established that no relationship ($p>0.10$) is evident between distance running performance and vital capacity. Earlier research conducted by Costill et al. (1973) concluded that a significant correlation ($r=.98$) existed between percent maximum heart rate when running 268 meters per minute and distance running performance. The research team concluded that a relationship ($p< .01$) exists between lower heart rate and successful distance running performance. The subject's heart rates decreased 24 beats per minute following an endurance running program. Hickson et al. (1981) also indicated that a decrease in the heart rate at a submaximal speed, occurs within the first 3 weeks of endurance training. A further decrease in heart rate did not occur unless the intensity of the exercise program is increased after the three week period (Hickson et al., 1981).

Brodal, Ingjer and Hermansen (1977) suggested that the capillary supply of the muscle fibers of endurance trained athletes may be a determinant of success. They indicated that trained endurance athletes have 25 percent more capillaries around each fiber than untrained athletes. Thus by having more capillaries the mitochondria are more adequately supplied with oxygen at a sustained an intensity level for longer periods.

Daniels (1985) suggested that running economy is related to distance running performance. Economy is a measure of the submaximal aerobic demand during different conditions. An economical runner can maintain a slightly faster pace than a less economical runner at the same submax VO_2. Evidence of this exists when comparing the elite athletes Steve Prefontaine and Frank Shorter who both ran similar times at the world class level. Prefontaine had a VO_2 max of 80 kg/ml/min, while Shorter had a VO_2 max of 70 ml/kg/min. Shorter was able to run at the same pace with a lower maximal oxygen consumption because he was a more economical runner (Bowerman, 1991) In a 10,000 meter race, a small difference in economy could lead to a large difference in finishing time (Conley, Krahenbuhl, Burkett, 1981). Williams and Cavanagh (1987) indicated that significant ($p<0.05$)evidence exists between variations in oxygen consumption and mechanical differences in running. Williams and Cavanagh also stated that changing a runner's form is correlated (r= .54) with an improved physiological economy. Conley, Krahenbuhl, and Burkett (1981) found similar evidence that changes in economy can improve distance running performance. Conley et al. defined economy as the average steady state VO_2 during the last 3 minutes while running at 241, 268, and 295 m/min. The researchers found that after a 18 week training program consisting of interval and endurance running, the runner's submax VO_2 at each of the running paces decreased 7.6, 7, and 5.1 ml/kg/min, respectively.

Biological Principles of Training

In order to increase the physiological states of muscles and cardiopulmonary system, the runner must be stressed at an intensity and duration level greater than normally encountered (Vigil, 1995). All training systems are composed of three physiological laws: 1) law of overload; 2) law of specificity; and 3) law of reversal.

The overload principle states that improvement requires an increase in training load to act as a stimulus to increase the body's anaerobic or aerobic pathways (Gambetta, 1981). Overloading a distance runner utilizes the body's response of achieving a higher level after recovering from a previous stimulus (Gambetta, 1981). The tissues which are exposed to the stress will fatigue. After the proper amount of rest, the tissue will compensate to the stress by operating at a higher physiological level (Vigil, 1995). This process of overcompensation by the body is what the principles of distance training are built upon (Gambetta, 1981). The most important factor in the overload principle is determining how much time the athlete requires to properly recover between sessions (Gambetta, 1981).

The law of specificity states that the nature of the training load determines the training effect. Therefore, training must be tailored to meet the specific effect desired (Freeman, 1989). The 10,000 meter run is an event which occurs at a velocity close to a runner's maximal oxygen consumption. The energy cost to run 10,000 meters is about 90 percent aerobic and 10 percent anaerobic (Fox, Bowers, & Foss, 1993). Anaerobic training is important for the 10,000 meter runner because in international competition the finishing place is often determined in the last 400 meters. Elite 10,000 meter runners are capable of running their last 400 meters at 53.5 to 54.9 seconds (Vigil, 1995). Thus, athletes must be well prepared anaerobically to maintain physical and mental contact with his or her competitors.

The law of reversibility claims that the fitness level of an individual will decline if proper training load does not continue. According to Freeman (1989), if the training does not become more challenging, the fitness level of the runner will plateau or decrease. As the training level improves, the level of performance of the athlete will improve (Gambetta, 1981).

Periodization

The development of the biological principles of distance training should follow a systemized approach to peak the distance runner. Many athletes use a process known as periodization, which is a system of dividing the athlete's training program into a number of sections that have a specific goal. Periodization divides the runner's training year into increments of time with specific tasks that attempt to cause physiological changes. Each section prepares the athlete for the following section until the athlete reaches a peak performance. Garvey (1995) claims that periodization is necessary for a distance runner to achieve success. Vigil (1995) states that periodization has two purposes: 1) to enable the athlete to reach his or her potential; and 2) to achieve peak performance at the correct time. With periodization the coach and athlete can assign workloads followed by a test to see if he or she is ready for the next step in training (Garvey, 1996) Proper implementation of periodization can help the athlete set realistic goals and reduce the potential for injury (Vigil, 1995). One of the most important concepts of periodization is that the athlete must have uninterrupted training at different intensities throughout the year in order to achieve elite status (Vigil, 1995). The training year of the runner can be divided into the following various components from largest to smallest: macrocycle, mesocycle, period, phase, microcycle, session, and unit. Each component attempts to quantify a more detailed training protocol for the athlete as he or she strives to obtain his or her goals. Many coaches utilize an annual plan that is planned on the bases of competition throughout the year's training structure (Gambetta, 1981; Vigil, 1987; Freeman, 1989)

The training of American cross-country season can be divided into the phases of transition, preparatory , and competition. Special considerations for the peaking period will be included in the review of literature of the stages of periodization because it appears to be the differentiating measure of success for distance runners (Freeman,1989). Refer to Figure one for the components of a single peak periodization.

Macrocycle						
Phases	Preparation		Competition			Transition
Periods	General	Specific	Precompetition	Competition	Peak	Transition
Microcycles						

Figure 1. Components of periodization of distance runners

Preparatory Phase

Lasting approximately three to four months, the preparatory phase is the longest of the phases of a runner's development. Its main purpose is to increase the functional aerobic capacities of the athlete (Gambetta, 1981; Vigil, 1987; Vigil 1995). According to Vigil (1987), this phase is very important because long distance runners cannot achieve success without a high VO_2 max. As maximum oxygen capacity increases the fuel utilization of the runner is altered by increasing the mitochondrial content of the muscle fibers, slower utilization of blood glucose and a greater reliance on fat oxidation when running submaximally (Hollozy and Coyle, 1984). These adaptions that result during distance training play an important role in the ability of a runner to perform prolonged exercises according to Hollozy and Coyle (1984).

The aerobic workouts are aimed at improving the runner's economy (Gambetta, 1981; Vigil, 1987). Hickson, Bomze and Holloszy (1977) stated that endurance training is important for an increase in the VO_2 max. Their sedentary subjects were required to exercise six days a week for a ten week period. Exercise consisted of alternating cycle ergometry and running. Cycling was done for six 5 minute intervals, while running was done for 30 to 40 minutes as fast as possible. Hickson et al. indicated that a linear increase in maximal oxygen consumption of 16.8 ml/kg/min during the ten week period. According to Gaesser and Rich (1984) VO2 max will increase with endurance training independent of the intensity. Their subjects were separated into two groups of high intensity running at 85 percent of VO_2 max for a 25 minutes, and low intensity running at 45 percent of an individual's VO_2 max . Their research indicated an average increase in VO_2 max at the two intensities was 19.6 percent and 17.7 percent respectively after 18 weeks. Thus Gaesser and Rich (1984) concluded that either intensity can be used to increase a runner's VO_2 max. However, the sample pool that Gaesser and Rich used was composed of subjects that had not been involved in any form of physical activity for 6 months prior to the study. Fox et al. (1973) agreed with the findings of Gaesser et al., that VO_2 max can be increased with endurance running. However, they stated that the higher intensity endurance running provides a more significant ($p<0.05$) improvement in VO_2 max than low-intensity running. Fox et al.'s high intensity group increased their VO_2max 3.6 $\pm$ 3.6 ml/kg/min, while the low intensity group only increased their VO_2 max 2.4 $\pm$ 3.3 ml/kg/min. Higher intensity distance running appears to be one of the elements of Kenyan success in running. Kenyan high-school runners spend over 50 percent of their training time with heart rates above 90 percent of his or her maximum heart rate (Anderson, 1996).

The preparatory phase appears to be the most reliable indicator of the success of the distance runner in the latter two stages of periodization (Gambetta, 1981). Bowerman (1991) stated that endurance running that occurs in the preparatory phase must be first developed or other types of training cannot be repeated enough to promote the other components of distance running fitness. Thus, there is controversy in the prescribed volume and types of training that will best prepare the athlete for the competition phase. Gambetta (1981) stated that the first two months of the preparatory phase are characterized by the development of a high training volume at a moderate intensity. Kinuthia and Anderson (1994) stated that American distance runners are not running as many miles during the preparatory phase as their Kenyan counterparts. Their survey of Kenyan distance runners indicated that Kenyans are running a minimum of 140 miles per week during the preparatory phase. Karikoski (1985) surveyed the association between the training volume of distance runners and their competitive performances. He indicated that elite Soviet distance runners are also averaging a high volume of training mileage, 3665 to 6200 miles per year. However, based on the survey data collected, no significant correlation between performance and training volume was found for elite athletes (Karikosk, 1985). Therefore, suggensting that an increased training volume helps to improve performances only up to a certain limit.

Fartlek training is a Swedish word for "speed play" that is often included in the preparatory phase of distance running to increase the endurance of the athletes. Fartleks are traditionally endurance runs that are interspersed with repetitions of increased intensity for 50 to 400 meters (Doherty, 1953). Therefore fartlek training can build both aerobic and anaerobic metabolic pathways. Robison et al. (1974) claim that fartleks obtain the best results when used twice a week during the preparatory phase. Robison et al. (1974) also stated that one should forget the stopwatch and run according to how he or she feels.

Vigil (1995) stated that the preparatory phase should consist of three various types of distance running. Vigil's three styles of volume training are 1) slow continuous running where the runner runs at a steady state (130 to 150 beats per minute) for one to two hours, 2) medium continuous running (140 to 160 beats per minute) for ten to twelve miles, and 3) fast continuous running (150 to 170 beats per minute) for six to ten miles. Runners must continue to train at a threshold to maintain their VO_2 max throughout the remainder of the year or the law of reversal will result (Vigil, 1987). The second two months of the preparatory phase begin to elevate the athlete's abilities for competition. It is in the second two months that the athlete develops specific adaptive changes to meet the physiological and motor skill demands of the 10,000 meter event.

Sinkkonen (1981) agrees with Vigil that the preparatory phase should initially begin with volume and end with speed endurance training. Sinkkonen states that volume should last for 26 weeks with 120 miles or more weekly. Anaerobic training during the preparatory phase is designed to improve the runner's rhythm and speed.

Competition Phase

The competition period lasts approximately four months and is characterized by a dramatic reduction in the training volume (Gambetta, 1981). Gambetta states that the time an athlete can continue to maintain performance levels is dependent upon the preparatory work to reach the current level (Gambetta, 1981). Therefore, the main goal of this phase is to maintain the consistent competitive form required during a period of major meets or qualifying trials. During this phase, the training volume is decreased in order to regenerate the athlete and allow the systems to replace organic and cellular energy (Vigil, 1987).

In 1991, Martin stated that running seven-minute- mile for a hundred miles a week is not going to allow American runners to compete at the international level anymore. (Bowerman, 1991) Thus much of the training methods of distance runners during the competition phase has shifted to a combination of interval work and endurance training to compete at the world class level. Much attention by American coaches on African distance running, has focused on the mileage run and not the speed development (Anderson, 1996) However, Anderson (1996) claims that African runners emphasize speed development more than the rest of the world. An example of the African training theory is evident from a Moroccan coach who stated that he would not accept any international runner as an athlete under his coaching unless he could run five successive 200 meter intervals in less than 28 seconds (Anderson, 1996). Even though distance races are considered endurance tests, speed is of vital importance (Robison, 1974), especially when world class athletes are averaging 4 minutes and 20 seconds per mile in a 10,000 meter race (Bowerman, 1991) Long distance running is no longer a refuge for untalented runners.

Daniels and Scardina (1984) stated that there is a widespread misunderstanding as to what exactly is involved in interval training. There are a variety of concepts of interval training. The only point of agreement between researchers, coaches, and athletes is that this type of training involves periods of alternating bouts of exercise and recovery. Daniels and Scardina (1984) stated that interval training does involve repeated bouts of work, each lasting between 30 seconds to 5 minutes, at an intensity of 95 to 100 percent of the runner's maximal oxygen consumption (Daniels & Scardina, 1984). However Brauman claims that a true interval workout never exceeds 400 meters. Mitchell (1979) claims that the best distance to be repeated during an interval workout is 200 meters.

Fox et al. (1973) indicated that a combination of endurance running and interval workouts significantly ($p<0.05$) increased VO_2 max by nine percent in distance runners. Fox et al. (1973) believed that the intensity of the interval program is more important than the distance of the interval to increase VO_2 max. Along with increasing the VO_2 max , interval training increases the neuromuscular coordination which is important for the economy of the runner (Frederick, 1973). Fox et al. (1975) indicated that frequency of interval workouts is independent ($p>0.05$)of increases in maximal oxygen consumption ($p< 0.05$). Running intervals twice a week or four times a week equally increase VO_2 max with no significant ($p<0.05$) difference between them (Fox et al., 1975). According to Knuttgen, Nordesjo, Ollander and Saltin (1973) interval training does not only increased the VO_2 max of the runner but also the lactate threshold (LT). Knuttgen et al.'s research concluded that a 1:1 work rest interval program would significantly ($p<.001$) elevate a runner's LT five percent if utilized for three days a week. Knuttgen et al.'s subjects decreased the amount of lactate in the blood from $13.3 \pm .05$ to $12.7 \pm .4$. Jacobs, Esbjornsson, Sylven, Holm and Jansson (1987) found similar results to Knuttgen et al. using interval training program with a 1:3 work relief ratio ($p< 0.05$) Knuttegn et al. (1973) also indicated that a decrease in heart rate ($p<.001$) by 6 to 10 beats per minute would occur in maximal exercise testing with interval training. By varying the intensity of the training session and the work:rest ratio during interval training, different amounts of lactate accumulation in the blood and different degrees of stress on aerobic and anaerobic capacities will occur (Daniels & Scardina, 1984).

Powers (1978) indicated that interval workouts are designed to raise the heart rate of the runner to 170-180 beats per minute for a short period at race pace or faster. Following this short interval, the runner rests until his or her heart rate drops to 120 beats per minute and then the next interval is run (Brauman, 1986). Daniels and Scardina (1984) disagree with Brauman (1986) on the definition of the rest period of interval training. They stated that the recovery periods are not determined by the heart rate of the runner but rather by time itself. Recoveries are kept relatively short and are shortened even further as fitness improves in the runner (Daniels & Scardina, 1984) If the workout is intended to develop greater cardiovascular endurance, the interval is lengthened; if the emphasis is on development of anaerobic power, the interval is shortened (Powers, 1978).

There is further controversy in what is called an interval workout and which is termed a repetition workout. Some researchers and coaches claim that difference between interval training and repetition training is the intensity of the workout (Daniels & Scardina, 1984). Repetitions are run for three minutes or less at race pace or faster with a complete recovery rest interval (Brauman, 1986; Bowerman, 1991; Daniels and Scardina, 1984). Repetition workouts are tailored to result in pace judgment and to develop strength and aerobic capacity (Daniels and Scardina, 1984).

Robison et al. (1974) and Brauman (1986) stated that hill training during the competition phase is the best method for developing anaerobic fitness. Martin (1991) claims that hill running requires the runner to utilize his or her arms, legs, and trunk muscles in a biomechanical motion that mimics dramatic pace changes that occur during racing. Robison et al. (1974) described hill workouts as training on a half mile hill with a two to three percent grade. Martin (1991) stated that there are three different types of hill workouts: undulating hills found on road runs, short steep hills and long manageable hills as described by Robison et al.

The competition phase has an increase in the intensity, which predisposes the runner to an increased chance of injury. Therefore it is important for the runner to have an appropriate amount of rest in between intense exercise sessions. Anderson (1996) stated that the biggest problem runners and coaches have is dividing workouts between speed and mileage running. Anderson claims that most injuries result when the runner attempts to perform a high speed session on legs that have already been fatigued with an excessive accumulation of miles. Bowerman (1991) stated that most athletes can operate on a hard-easy principle. However the easy or rest period is dependent on the athlete. Some athletes may require two days of rest, while others are extremely durable and can practice at a high intensity two days for every easy day (Bowerman, 1991).

Peaking Period

Athletes who are labeled as successful are able to reach a prime fitness level for specific events. Being able to successfully develop the athlete's physiological and psychological attributes for one specific competition is known as peaking. Sheeply et al. (1992) indicate that a seven day high intensity taper is significantly ($p<0.05$) better in peaking an athlete's performance than low intensity tapers or rest only tapers. The high intensity tapered runners were able to increase their total running time before fatigue set in by 22 percent, while the low intensity tapered runners were able to only increase their time by six percent. Anderson (1995) agrees with the seven day tapering method because physiological benefits of exercise usually are not demonstrated for at least seven to ten days after a workout. Vigil (1995) states that a tapering period takes four weeks rather than seven days. Kinuthia and Anderson (1994) indicated that Kenyan runners average 40 to 50 miles per week when preparing to peak for the world cross-country championships. The majority of the miles run during the peaking period by the Kenyan runners consist of fartlek and interval training. Anderson (1995) stated that intensity is the more important than volume to keep the athlete in peak performance. Cullinane, Sady, Vadeboncoeur, Burke and Thompson (1986) stated that an absence of activity ten days before competition will not alter an athlete's VO_2 max . They concluded that VO_2 max will not decrease in the distance runner if previous training was at a high enough intensity. Even though the researchers did not find that VO_2 max was altered ($p>0.01$), they did indicate that peak exercise heart rate was elevated 9 ± 5 beats per minute. An increased heart rate occurred because of a decrease in plasma volume of 5 percent after two days of exercise cessation. Further decreases in plasma volume did not occur after two days of inactivity ($p<0.01$).

Transition Phase

The transition phase is the portion of the distance runner's annual training program where he or she recuperates before the start of the next preparation phase (Bowerman, 1991) During this phase there are no event training activities so that the runner can recover from the psychological and physical stress of competition (Bowerman, 1991). The transition phase also serves to eliminate the possibility of overtraining (Vigil, 1995) The runner will be involved in training that is low-key and only provides a transition to the next microcycle (Freeman, 1989). If the training year has more than one peaking period then the transition period is short and may be limited to a week (Freeman, 1989). However Freeman (1989) recommends that the transition period last at least one month. Fox, Bowers, Foss (1993) stated that the transition phase should consist of non-specific activities that only require that the athlete keep moderately active. Fox et al. suggest that running should be performed at a low intensity for no more than two to three times a week. Vigil (1995) stated that the athlete must come out of the phase well rested, and injury free so that he or she can undertake the difficult training program of the following macrocycle.

Coyle (1990) stated that approximately half of the endurance training benefits may be lost if the runner's training is discontinued for two weeks. Even though the athlete's body will readjust to meet the lower physiological demands, detrained athletes can maintain training-induced adaptations in heart size and muscle capillarization for at least three months (Coyle, 1990) VO_2 max in highly trained athletes will decline rapidly during the first month of inactivity (Coyle, 1990). Thus it is better that the training frequency be reduced during the transition phase rather than discontinuing training (Coyle, 1990).

Summary

Successful distance runners are characterized by a high VO_2 max, elevated lactate threshold, lower submaximal exercise heart rate, higher percent of slow twitch fibers, and an efficient economy. Economy is defined as a low oxygen cost of running at a submaximal speed. Development of a successful distance runner follows three biological laws of training: 1) law of overload; 2) law of specificity; and 3) law of reversal. The use of the biological laws of training are formulated into a systematic approach of training is referred to as periodization. Periodization consists of a preparatory phase, a competition phase, and a transition phase. Each phase prepares the runner for the following phase until he or she reaches a peak physiological and psychological form.

The preparatory phase last for approximately four months and is characterized by an increase in training miles. Fartlek training, which allows a runner to build both anaerobic and aerobic capacities, is also a training method of choice during the preparatory phase. It appears that American distance runners are not running as many miles during the preparatory phase as the Kenyans.

The competition phase lasts approximately four months and is highlighted by a dramatic reduction in training volume. The main goal of this phase is to develop and maintain a competitive form. Much of the training during the competition phase is composed of interval, repetition, and hill training.

The peaking period is a portion of the competition phase where the runner has develops psychological and physiological attributes for one specific competition. During this phase, reduction in training volume is significant. The majority of the miles run by Kenyan distance runners during this period consist of fartlek and interval training sessions. Research indicates that a seven day taper is appropriate for peaking. However, Vigil recommends a four week tapering period in order to fully develop the runner to reach the goals he or she has established.

The transition phase gives a runner a chance to recuperate before the start of the next preparatory phase. During this phase there are no competitions, but only light activities that provide transition to the next microcycle.

CHAPTER IV
PROCEDURES

Subjects

Selection of teams was established after the district cross-country championships. District competition was open to any Division I team or individual in the district that wanted to participate. Teams competing in the districts were composed of seven runners each. The top two teams from each district 10,000 meter race automatically qualified for the national championship finals. One additional team qualified from districts 2, 3, and 4. Twenty-two non-qualifying teams were randomly selected from the eight districts for comparison of training methods with the teams that qualified. The coaches of the teams, were contacted directly by mail or recruited by direct contact. Prior to data collection, the survey was reviewed by the IRB. Receipt of a survey by the coaches implied that the participant had perceived informed consent about the research he or she was participating. Therefore, no informed consent form was sent to the coaches. The surveys were returned after the national cross-country meet by self-addressed stamped envelopes.

Experimental Design

Surveys were sent to the coaches of national championship qualifiers and non-qualifiers to evaluate the training methods of the team. The survey consisted of questions that described the training methods used in the transition phase, competition phase and peaking period. Initially, individual team differences and success at the national championship level were evaluated. The top 7 and bottom 7 teams were compared to see if any difference in their training methods may have been related to success at the national level. The training methods of the qualifiers and non-qualifiers was compared to determine if a significant difference existed that may have predisposed a team to qualify for the national championship meet. The team mean times of the qualifting teams were correlated with various types of training methods to determine what variables are related to success. Analysis of the frequency of training methods was correlated with team rank at the national meet to determine if frequency of the training variables were related to success. Based on the survey data of the national qualifiers, the analysis attempted to predict the finishing time of teams at the national cross-country meet.

Data Collection

Dr. Jack Daniels, a well-respected researcher and coach from Cortland State University, endorsed the study. A cover letter indicating the purpose and value of the study and its implications for the running population, along with the letter from Dr. Daniels implicating the worth of the study was sent with the survey. Refer to appendix A for the survey cover letter and Dr. Daniel's letter. The survey was designed to characterize the team's average weekly and monthly training program. Information was sought for the transition phase, competition phase and peaking period of the training cycle. The participants were asked to return the survey by mail after the national cross-country meet. Individuals responding to the survey were informed that their individual results will be held confidential. Refer to Appendix B for the distance running survey. The survey was validated by sending it to six NAIA and NCAA Division II coaches from Nebraska.

Statistical Analysis

Descriptive statistics were calculated using mean scores from training data for the qualifying teams. Descriptive statistics helped to establish values that were most representative of the survey respondents.

A Pearson correlation and multiple regression were used to determine correlations between mean team time and various training indices obtained from the survey. The Pearson correlations that were significantly related to 10,000 meter performance were further analyzed by calculating a coefficient of determination. All statistical analyses were conducted with a two-tailed test that had an alpha level of 0.05.

A Spearman rho analysis was performed on the ranked teams and frequency of the training methods. The Spearman rho was used to determine the correlations between frequency of use of training methods and rank at the national cross-country meet. The correlations that were significantly related to team rank were further analyzed by calculating a coefficient of determination.

To determine the significant differences between the training methods of the top seven teams and bottom seven teams an independent t-test was used. An independent t-test was also used in a similar fashion to compare the training methods of the non-qualifiers and qualifiers of the national cross-country meet. To indicated the magnitude of the difference of the significant t-test an omega squared was conducted.

Multiple regression analysis was used to determine the variance explained by the survey items. Variables were added until further addition of variables no longer significantly added to the explained variance. Based on the data obtained from the survey, multiple regression was performed with the various training methods to predict the mean finishing time of the teams and determine the variance in performace explained by various training variables.

CHAPTER V

RESULTS

Surveys were collected for four months (November to February). All but one survey was full completed. The descriptive characteristics of the NCAA national meet qualifiers (n=14) for the transition phase and competition phase are listed in Tables III and IV. The qualifier's mean team time for the national cross-country meet was 33.16 $\pm$ 0.9 minutes.

<u>Table III.</u> Transition phase training methods of NCAA Division I cross-country runners.

	Mean	SD	Min	Max
Total miles/week	59.5	10.6	43.1	80.0
Longest Run (miles)	11.5	2.1	7.1	15
<u>Average number of days per week of:</u>				
Tempo	1.1	0.8	0.0	3.0
Short and Easy Running (other than warm-up and cool-down)	1.9	2.1	0.0	15
Repetitions	0.1	0.3	0.0	1.0
Intervals	0.1	0.3	0.0	1.0
Hills	0.6	0.7	0.0	2.0
Fartlek	0.5	0.5	0.0	1.0
Cross-Training	0.5	1.6	0.0	6.0
Drills	1.3	2.0	0.0	7.0
Weights	1.5	1.4	0.0	4.0
Rest	0.5	0.5	0.0	1.0
Practice held twice a day	1.5	1.9	0.0	4.5

Table IV. Competition phase training methods of NCAA Division I cross-country runners.

	Mean	SD	Min	Max
Total miles	72.4	9.14	55.00	85.00
Longest Run (miles)	13.4	2.24	9.00	16.00
Mean number of days per week of:				
Tempo	1.6	1.37	1.00	6.00
Short and Easy Running (other than warm-up and cool-down)	2.1	1.77	0.00	5.00
Repetitions	0.7	0.63	0.00	2.00
Intervals	0.8	0.60	0.00	2.00
Hills	0.6	0.65	0.00	2.00
Fartlek	0.7	0.47	0.00	1.00
Cross-Training	0.3	0.63	0.00	2.00
Drills	1.6	1.26	0.00	3.00
Weights	1.8	0.89	0.00	3.00
Rest	0.3	0.46	0.00	1.00
Practice held twice a day	3.5	1.50	0.00	6.00

Peaking period characteristics of the NCAA qualifying teams are described in Table V. The peaking data for each team was pooled over four weeks. The total miles and longest runs during the period were summed and averaged, while the frequencies of the training methods period were only summed.

Table V. Peaking period training methods of NCAA Division I cross-country runners.

	Mean	SD	Min	Max
Total miles/week	58.9	10.3	45.0	77.5
Longest Run (miles)	10.9	1.3	8.7	14.0
Total number for 4 week training phase:				
Tempo	2.3	2.0	0.0	8.0
Short and Easy Running (other than warm-up and cool-down)	11.2	7.1	0.0	20.0
Repetitions	2.4	2.4	0.0	8.0
Intervals	2.7	2.0	0.0	6.0
Hills	1.2	4.2	0.0	16.0
Fartlek	0.6	0.9	0.0	3.0
Cross-Training	0.7	1.9	0.0	6.0
Drills	5.3	5.9	0.0	19.0
Weights	3.6	3.3	0.0	10.5
Rest	2.8	1.6	0.0	4.0
Practice held twice a day	7.1	5.4	0.0	17.0

Independent t-tests were conducted for the training methods during the various phases for qualifying (n=14) and non-qualifying (n=16) teams. Differences in the various phases are indicated in Table VI. Significant differences ($p<0.05$) in the transition training methods existed for the longest run per week with the non-qualifing teams running longer than the qualifying teams. The qualifiers ran significantly more miles per week than non-qualifers during the competition ($p<0.05$).

Table VI. Differences in training methods of the qualifiers and non-qualifiers during the transition and competition phases (M ± SD).

Training Phase and Method	Non-Qualifiers (n=16)	Qualifiers (n=14)	t ratio	Omega^2
Transition Phase				
Longest Run/week	13.7 ± 1.7	11.5 ± 2.1	2.97*	16.5
Competition Phase				
Total Miles/week	62.7 ± 10.6	72.4 ± 9.1	-2.63*	13.1

* Significant at 0.05 level

An independent t test was also performed to determine if any training differences existed between the top seven qualifying teams and lower seven qualifying teams. No significant differences ($p>0.05$) between the top seven and lower seven qualifying teams were found for the transition phase. Differences in the competition phase is indicated in Table VII. Significant differences occurred during the competition phase for fartleks and repetition workouts. The lower seven teams used fartleks as a training method more often than the top seven teams. The top seven teams used repetition workouts more often during the competition phase than the lower seven teams, while the lower seven teams used interval training more often than the top seven teams. During the peaking period the top seven teams significantly ($t= 2.20$; $p<0.05$) used fartlek training more often than the bottom seven teams. The top seven teams used fartlek training 1.17 $\pm$ 1.17 times during the peaking period, while the lower seven teams used fartlek only 0.143 $\pm$ 0.38 times during the peaking period.

Table VII. Differences in the various training methods during the competition phase of the top seven and lower seven qualifying teams (M $\pm$ SD).

Training Method	Top Seven Qualifiers	Lower Seven Qualifiers	t	p	Omega^2
Repetition	2.5 $\pm$ 2.2	0.57 $\pm$ 2.2	2.29	0.05	23.3
Intervals	0.33 $\pm$ 0.52	1.14 $\pm$ 0.37	3.26	0.05	40.8
Fartlek	0.33 $\pm$ 0.52	0.95 $\pm$ 0.12	3.09	0.05	37.9

Correlations between the training methods and team mean time during the transition phase are listed in Table VIII. Significant positive correlations were found with tempo, repetitions, intervals, fartleks, and practice held twice a day. A positive correlation indicates that the more teams used tempo, repetitions, intervals, fartlek and practcing twice a day, the slower the team mean time.

Table VIII. Correlations for transition phase training methods and team mean time

	r	r^2x 100
Total miles / week	0.27	7.5
Longest Run (miles)	0.36	13.0
Average Number of days per week of:		
Tempo	0.49	24.1
Short and Easy Running (other than warm-up and cool-down)	0.96	92.2
Repetitions	0.53	28.8*
Intervals	0.53	28.8*
Hills	-0.07	
Fartlek	0.54	30.0*
Cross-Training	0.01	
Drills	0.23	5.62
Weights	0.32	10.7
Rest	-0.02	
Practice held twice a day	0.63	40.7*

* Significant at the 0.05 level

Correlations between the training methods during the competition phase and the team performance time at the national meet are indicated in Table IX. Significant, positive correlations were found for repetitions and fartlek training. A positive correlation indicated that the more teams used repetitions and fartlek training the slower the team mean times.

Table IX. Correlations for competition phase training methods and team mean time

	r	r^2x 100
Total miles / week	-0.04	
Longest Run (miles)	0.29	8.58
Average Number of days per week of:		
Tempo	-0.35	12.2
Short and Easy Running (other than warm-up and cool-down)	-0.05	
Repetitions	-0.05	
Intervals	0.61	36.8*
Hills	-0.13	
Fartlek	0.69	47.5*
Cross-Training	0.04	
Drills	0.38	15.0
Weights	0.19	3.8
Rest	0.09	
Practice held twice a day	0.35	12.6

*Significant at the 0.05 level

Correlations between training methods and team performance time for the peaking period of the national qualifiers are indicated in Table X. A significant negative correlations was found for tempo training. A negative correlation indicated that the more teams used tempo and hill training to peak, the lower the mean times.

<u>Table X</u>. Correlations for peaking phase training methods and team mean time

	r	r^2x 100
Total miles	-0.33	11.1
Longest Run (miles)	-0.27	7.5
<u>Average number of days per week of:</u>		
Tempo	-0.61	36.8*
Short and Easy Running (other than warm-up and cool-down)	0.11	
Repetitions	-0.42	18.4
Intervals	-0.03	
Hills	-0.52	27.6
Fartlek	-0.25	6.2
Cross-Training	0.24	5.9
Drills	0.14	
Weights	-0.07	
Rest	-0.19	
Practice held twice a day	0.07	

*Significant at the 0.05 level

Based on the training data received from the qualifying teams, the team training methods and performance times were ranked. A Spearman rho was computed to see if any correlations existed between the order of finish and rank of the various training methods. Assessing success based on order may provide further insight about training methods that may be related to distance running performance. The correlations for order of finish and various training methods for the transition period are presented in Table XI. Significant positive correlations were found between fartlek training and practicing twice a day during this phase. A positive correltation indicates that the more teams practiced twice a day and used fartlek training during the transition phase, the lower or worse the finishing place at the national meet.

Table XI. Spearman r correlations of team finishing order and training method for transition phase.

	r	r^2x 100
Total miles / week	0.31	9.8
Longest Run	0.40	16.6
Average Number of days per week of:		
Tempo	0.44	19.5
Short and Easy Running (other than warm-up and cool-down)	0.14	
Repetitions	0.50	25.6
Intervals	0.50	25.6
Hills	0.44	19.5
Fartlek	0.57	33.1*
Cross-Training	-0.18	
Drills	0.29	8.9
Weights	0.29	8.8
Rest	-0.05	
Practice held twice a day	0.56	31.9*

*Significant at the 0.05 level

The Spearman r correlations for order of finish and training methods during the competition phase are indicated in Table XII. Significant positive correlations were found for intervals and fartlek training. No significant correlations were found between finishing order or total miles run and longest run during the competition phase.

Table XII. Spearman r correlations of team finishing order and training method for competition phase.

	r	$r^2 \times 100$
Total miles	-0.08	
Longest Run (miles)	0.36	13.0
Average Number of days per week of:		
Tempo	0.15	
Short and Easy Running (other than warm-up and cool-down)	-0.20	4.2
Repetitions	-0.08	
Intervals	0.63	40.2*
Hills	0.03	
Fartlek	0.67	45.2*
Cross-Training	-0.02	
Drills	0.39	15.8
Weights	0.27	7.6
Rest	0.11	
Practice held twice a day	0.31	10.1

*Significant at the 0.05 level

Spearman r correlations between the finishing order and the various training methods during the peaking period are indicated in Table XIII. A significantly negative correlation was found for interval training. A negative correlation inidcates that the more intervals were used as a training method during the peaking period, the higher finishing place a team had at the national cross-country meet.

Table XIII. Spearman r correlations of team finishing order and training method for peaking period.

	r	$r^2 \times 100$
Total miles	0.31	
Longest Run (miles)	0.12	1.5
Average Number of days per week of:		
Tempo	0.21	4.8
Short and Easy Running (other than warm-up and cool-down)	-0.15	2.5
Repetitions	0.02	
Intervals	-0.65	41.7*
Hills	0.07	
Fartlek	0.23	5.7
Cross-Training	0.09	
Drills	0.20	4.0
Weights	0.36	13.5
Rest	0.20	
Practice held twice a day	0.18	

*Significant at the 0.05 level

A multiple regression analysis was performed on the transition training methods of the qualifying teams (n=14). The best predictors of team performance (Y=mean time) were practicing twice a day, drills, tempo, and short easy runs. The regression equation is indicated in Table XIV. Positive correlations indicate a slower mean team time while negative correlations indicate a faster mean team time. Consequently, practicing twice a day, tempo and weights were associated with a slower team time, while drills and short easy running were associated with a faster mean team time. The equation based on transition phase training methods was able to predict mean team time at the national meet within 36 seconds.

Table XIV. Stepwise multiple regression analysis to predict final team time based on transition data

Equation	R	R2	SEE
Y = 32.68 + 0.361 (P)	.69	47.88	0.70
Y = 32.73 + 0.607(P) - 0.28(D)	.81	65.50	0.60

P = Practice held twice a day

D = Drills

A multiple regression analysis was performed on the training methods of the qualifyers during the competition phase in order to predict team performance. The equations in Table XV indicate that fartlek and practices held twice a day during the competition phase are the best indicators of team performance. A positive correlation inidcated that an increase in mean time is associated with practicing twice a day and using fartlek training during the competition phase. The equation based on the competition phase training methods was able to predict the mean team finishing time within 38.9 seconds.

Table XV. Stepwise multiple regression analysis to predict final team time based on competition phase data

Equation	R	R2 x 100	SEE
Y = 32.24 + 1.34(F)	.67	45.47	0.742
Y = 31.26 + 1.41(F) + 0.26(P)	.79	62.41	0.649

F = fartlek

P = Practice held twice a day

A multiple regression analysis was also performed on the peaking methods of the qualifiers in an attempt to predict team performance. The equation in Table XVI indicates that tempo workouts during the peaking period are the best predictor of team performance. Thus the use of tempo training is associated with a faster mean team time at the national cross-country meet. The equation based on the peaking training methods of the teams was able to predict the mean team time at the national meet within 37.8 seconds.

Table XVI. Stepwise multiple regression analysis to predict final team time based on peaking data

Equation	R	R2 x 100	SEE
Y = 33.64 - 0.267 (T)	.68	47.14	0.63

T = Tempo

Further analysis of the qualifying teams' performance was done by performing a multiple regression on the training methods for the entire cross-country training year (May to November). The equation in Table XVII indicates that practicing twice a day, resting and weight training during the transition results in a slower team time at the national meet. However, the use of hill training during the transition phase is associated with a faster team time. The cross-country season equation was able to predict the mean team time within 27 seconds. The equation also suggests that the long distance running and cross-training during the tranisition phase may result in a slower team time. The equation inidicated that the transition phase may be the most important indicator of difference in team times at the national cross-country meet.

Table XVII. Stepwise multiple regression analysis to predict final team time based training methods for the entire cross-country year.

Equation	R	R2 x 100	SEE
Y = 32.54 + 0.3421(P)	.70	49.78	0.624
Y = 32.74 + 0.4357(P) - 0.565(H)	.87	76.84	0.449

P= Practice held twice a day during transition phase

H= Hill training during transition phase

CHAPTER VI
DISCUSSION

The present study resulted from the need to better understand the relationship of various training methods throughout the cross-country season (May to November) on 10,000 meter performance. Previous research related to distance running usually has been limited to a periods lasting 8 to 18 weeks. Past research has largely ignored that distance runners don't just train for 8 to 18 weeks, but rather for months to reach a peak performance. The Berg, Latin and Hendricks (1995) study is one of the few studies that actually conducted a longitudinal assessment of the changes in physiological and physical variables of distance running performance. Berg et al. indicated that significant physiological and physical changes occur throughout the training year. Research similar to Berg et al. is lacking in the literature. Slovic (1977) and Pollock (1978) appear to be the only studies that attempted to analyze training methods in relation to performance with a survey. Slovic's methods of predicting marathon performance were based mostly on the total miles run during various months and fastest 5 and 10 km times. Slovic's study did not include other forms of training that runners may use, such as multiple regimens of training, interval training, pace work and lactate threshold training. Pollock described the frequencies of interval training and total mileage of elite distance runners but was unable to correlate the data with performance.

The current study of 14 national qualifying NCAA Division I teams revealed a description of the training principles of elite collegiate athletes as they attempted to prepare and peak for the national cross-country championship. The survey analysis divided the season into the transition phase (May to August), competition phase (August to October), and peaking period (November).

Surveys were gathered from qualifiers (n=14) and randomly chosen non-qualifiers (n=16) to determine if a difference in the training methods may have predisposed one team to qualify over another. Compared to the non-qualifiers, qualifiers ran a significantly shorter distance ($p<0.05$)on their long distance days during the transition phase. Non-qualifiers averaged 13.8 $\pm$ 1.79 miles while qualifiers averaged 11.6 $\pm$ 2.12 miles. Since the total mileage between the qualifiers and non-qualifiers was not significantly different ($p>0.05$), this tends to indicate that the non-qualifiers are spending more of the transition phase running long, slow distances. However, according to Conley, Krahenbuhl, Burkett and Millar (1984), changes in VO2 max and LT in athletes are dependent on the intensity of endurance running. Long, slow distance running may possibly be a detractor for VO2 improvement and maintenance during the transition phase. Higher intensity and shorter endurance runs may be more beneficial in the improvement and maintenance of VO2 max and other physiological factors. Distance training ideology has been built upon the thought that longer is better (Karikosk, 1985). Our finding may argue against such methodology.

Additional significant differences between the qualifiers and non-qualifiers were noted during the competition phase. Qualifiers ran significantly ($p<0.01$) more miles during the competition phase of training. Qualifiers averaged 72.4 ± 9.1 miles per week while non-qualifiers averaged 62.7 ± 10.6 miles. This difference in mileage probably is not due to longer runs or running twice a day since no significant ($p>0.05$) differences were found in these categories. It is interesting to note that the non-qualifiers were averaging a similar amount of mileage during the competition phase (62.7 ± 10.6) and transition phase (59.3 ± 12.9 miles). It appears as if the non-qualifiers did not reach a higher level of training by changing their mileage. Rather, they maintain a consistent mileage base throughout the season. The lack of mileage fluctuation during the various phases suggests that periodization is important for distance running performance.

No significant ($p>0.05$) differences between the non-qualifiers and qualifiers was found during the peaking period.

Correlations with performance

The various training methods were correlated with performance to determine which training methods throughout the season would have a significant relation with distance running performance. During the transition phase repetitions, intervals, fartlek and tempo training were found to have a significant ($p<0.05$) positive relationship with performance at the end of the season. The positive correlation for these variables suggested that the more that these methods are used during the transition phase, the slower the time at the end of the season. Repetitions, intervals, tempo and fartlek training explained 28.8 percent, 28.8 percent , 30.0 percent and 24.1 percent variation in team times at the national meet, respectively. This evidence supports statements by Bowerman (1991), Freeman (1989), Vigil (1995), and Fox et al. (1993) that the main purpose of the transition period is to provide recovery and preparation for the next microcycle. The positive correlations also suggest that an emphasis of repetitions, intervals, fartlek and tempo training may be of limited value early in the training cycle. Perhaps the use of such training methods may also lead to overtraining in the athlete.

Practicing twice a day during the transition phase was also found to be significantly ($p<0.01$) related to distance running performance. A positive correlation ($r=.638$) with performance was found for practicing twice a day, which suggests that an athlete may not recover fully. An insufficient recovery may limit the overall intensity of the training. Practicing twice a day during the transition phase explained 40.7 percent of the variance in team performance at the national championship. The amount of mileage run during the transition phase was significantly ($p<0.05$) related to running twice a day ($r=.475$). This suggests that teams with a slower performance tended to practice twice a day in order to increase the amount of mileage run during the transition phase. This suggests that more mileage is not necessarily better.

A significant ($r=0.61$; $p<0.05$) positive correlation during the competition phase was found between the use of interval training and distance running performance. Frequency of interval training explained 36.8 percent of the variance in team time at the national meet. This suggests that the greater the use of interval training during the competition phase the slower performance times at the end of the season. Daniels and Scardina (1984) stated that there is a widespread misunderstanding about application of interval training. Interval training has been described as alternating work and rest periods. Identification of the best work to rest ratios to achieve specific physiologic qualities and how the ratios should be used throughout the training cycle remains largely unknown . Possibly interval training during the competition phase may have led to slower team times due to overtraining. Competition and interval training are performed at a high physiological intensity. A combination of bouts of interval training and competition may have caused overtraining which resulted in injury, illness or staleness of the team. However, whether or not it is associated with a slower performance time due to overtraining cannot be determined by this study.

Fartlek training during the competition phase also had a significant ($r=0.69$; $p<0.01$) positive correlation with performance time. The use of fartlek training during competition phase explained 47.5 percent of the variance in performance time at the national cross-country championship. The teams that used fartlek training during the competition phase tended to have slower performance times at the end of the season. The mean use of fartlek training by the qualifying teams during the competition was 0.7 times a week. The teams that used fartlek training to improve performance may not be using this method of training with enough frequency to gain performance benefits. Fartlek training during the transition phase of this study was previously found to be significantly ($p<0.05$) related to slower team times at the national meet. It may be speculated that fartlek was an ineffective training method during the transition and competition phases.

Choosing the correct method to reach a peak performance is controversial. A significant negative ($r= - 0.61$; $p<0.05$) correlation was found between the use of tempo training during the peaking period and distance running performance. Tempo training during the peaking period explained 36.8 percent of the variance in team times. Interestingly, research on tempo training and changes in physiological variables appears to be unavailable in the literature. The use of tempo training may be a method of training that has been overlooked by coaches and researchers alike. During tempo training an athlete trains at an elevated pace at the athlete's lactate threshold (Daniels,1997). Based on the results of this study, running at an elevated pace close to an athlete's lactate threshold may possibly be an essential ingredient in preparing the body to reach a peak performance. Sheeply et al. (1992) indicated that using a high intensity taper is significantly ($p<0.05$) better in peaking an athlete than a low intensity taper. Tempo training appears to be a type of high intensity training that promotes physiological peaking that needs further consideration by coaches and researchers.

Correlations of Rank in Performance and Training Methods

A Spearman rho statistical analysis of the rank of the various training variables was performed to further analyze correlations with performance. At the elite level many of the teams are separated by seconds which may mask true differences in training methods related to team performance. Analysis of ranked data may help to make differentiations among the success of teams at the national cross-country meet. Information from the various teams regarding transition phase training methods revealed a significant ($p<0.05$) correlation between fartlek training and rank of the qualifying teams. The positive correlation indicated that teams that placed lower at the national meet tended to use fartlek training more often than higher placing teams. Fartlek training explained 33.1 percent in the placement of teams at the national meet. This correlation suggests that fartlek training during the transition phase does not enhance distance running performance. Fartlek training during the transition phase tends not to be a beneficial training method for these athletes.

Further correlations for the transition phase revealed a significant positive ($r= .57$; $p<0.05$) correlation between practicing twice a day and team placement. Practicing twice a day during the transition phase explained 31.9 percent of the variance in team order. Thus, teams that practiced twice a day tended to have a lower rank at the national meet. This correlation suggests that practicing twice a day during the transition phase is not effective.

Evaluation of the training methods of qualifying teams during the competition phase indicated that the of use of fartlek training was significantly and positively ($r=.674$; $p<0.05$) related to team rank. Fartlek training explained 45.2 percent of the variance in team rank at the national meet. Teams that used more fartlek training during the competition phase placed lower at the national meet. This evidence supports the previous positive correlation ($r= .55$; $p<0.05$) of the use of fartlek training during the competition phase and mean team time. A lack of scientific literature is available on fartlek training methods. From this study's standpoint, fartlek training appears not to be an effective training method during the competition phase. The use of fartlek training may limit the amount of other forms of training that a team performs during the complete season.

The use of interval training during the competition phase has a significant positive ($r=.634$; $p<0.05$) relation to team rank at the national meet. Use of interval training explained 40.2 percent of the variance in the team finishing order. Teams that placed lower at the national meet tended to use interval training more often during the competition phase than higher placing teams. This evidence supports the previous positive correlations ($r=0.67$; $p<0.05$) for team mean time and interval training. Possibly the use of interval training during the competition phase may cause the distance runner to become overtrained. Competitive distance running at the Division I level often involves racing once a week. The intensity experienced during a cross-country race is similar to interval training where the runner is exerting at an effort close to VO2 max and above LT. Racing during the competition phase may serve as a method of training which increases or maintains the runner's VO2 max and higher than LT. An excessive combination of interval training and racing may cause a runner to become overtrained and hinder ultimate performance.

There appear to be no definitive guidelines in the literature about how interval training should be conducted. Interval training has been shown to increase VO2 max and LT (Knuttgen et al.,1973; Jacobs et al., 1987). However, many of the studies on interval training have used subjects that were untrained and non-competitive, and hence any regular aerobic activity may have improved VO2 max and LT. Daniels and Scardina (1984) stated that by varying the intensity of the training session, different amounts of stress on the aerobic and anaerobic capacities will occur with interval training. The work-to-rest ratio for training competitive distance runners needs to be further evaluated. Based on this study's findings, interval training during the competitive and transition phases is inversely related to success of distance running performance.

Contrary to the finding here that intervals are not an effective method of training during competition and transition phases, it does appear to have a significant negative ($r= - 0.65$; $p<0.05$) relation during the peaking period. Correlations of the use of interval training explains 41.7 percent of the variance of team finishing order. Therefore, teams that placed higher at the national meet used more interval training during the peaking period than teams that finished lower. This correlation suggests that higher placing teams used interval training more frequently when reaching a peak performance.

Differences between the qualifying teams

The 14 qualifying teams were divided into the top seven and lower seven teams to determine if there were any differences in the training variables that may have predisposed a team to have a better performance. No significant differences ($p>0.05$) were found between the top seven teams and lower seven teams during the transition phase.

Significant differences were found for the amount of interval training ($t= 2.29$; $p<0.05$) and repetition ($t= 3.26$; $p<0.01$) workouts used by the top seven and lower seven qualifying teams during the competition phase. The bottom seven qualifying teams were using interval training more often (2.50 ± 2.2 days per week) than the top seven qualifying teams (0.571 ± 2.2 days per week). This study has indicated that a significant positive correlation existed between interval training and mean team time ($r=.61$; $p<0.05$) and team rank ($r= 0.63$; $p<0.05$) during the competition phase. Therefore, the excessive use of interval training may not be an appropriate method for training distance runners during the competition phase. Previously it was stated that interval training was found to be negatively correlated ($r= -0.65$; $p<0.05$) with team rank during the peaking phase. Interval training probably aids peaking by elevating and maintaining the runner's VO2 max and lactate threshold. By using interval training during the competition phase, an athlete may peak before reaching the national meet. Peaking before the national meet may be related to coaches attempting to compete well at home cross-country meets and the district qualifying meet.

Interestingly, the top seven teams significantly ($p<0.05$) used repetitions more often (1.1 $\pm$ 0.38 days per week) during the competition phase than the bottom seven teams (0.33 $\pm$ 0.38 days per week). Therefore, the top seven teams tend to rely on repetitions rather than intervals for developing and maintaining the aerobic capacity of the runner. Repetition training remains a relatively unexplored area of training in the literature due to the controversy of what is termed an interval workout and what is termed a repetition workout. Daniels and Scardina (1984) and Bowerman and Freeman (1991) state that repetition workouts differ from intervals in the degree of the rest interval. Intervals are conducted with a specific work to rest ratio, while repetitions have a work with a longer, more complete rest interval. The use of repetitions during the competition phase may allow the runner to increase his aerobic capacity while allowing enough rest to prevent overtraining. Repetition training may also help the runner to sustain a psychological tolerance for the discomfort associated with high intensity distance running.

Further significant differences ($t= 3.09$; $p<0.01$) during the competition phase existed in the amount of fartlek training. The lower seven teams used fartlek training more often (0.95 $\pm$ 0.12 days per week) during the competition phase than the top seven teams (0.33 $\pm$ 0.52 days per week). Fartlek training had a significant positive correlation ($r= 0.68$; $p<0.01$) for mean team time and a significant positive correlation ($r= 0.674$; $p<0.05$) for team rank at the national championship. As previously stated, the use of fartlek training in the scientific literature remains an unexplored topic. Fartlek training during the competition and transition phase appears not to enhance the ultimate performance.

Interestingly, fartlek training was also significantly different ($t= 2.20$; $p<0.05$) between the top seven teams and lower seven teams during the peaking period. However, the top seven teams used fartlek training more often (1.17 $\pm$ 1.2 days per week) than the bottom seven teams (0.14 $\pm$ 0.38 days per week). This is the only evidence in this study of a possible unique value of fartlek training. This study has indicated that a significant ($p<0.05$) negative correlation exists for repetitions, tempo, and hill training and team mean time and rank. These types of training methods are performed at a high intensity. Fartlek training during the peaking period may serve as a type of low intensity workout between high intensity workout. However, as previously stated, further research on the physiological and performance changes that occur with fartlek training needs to be evaluated for distance runners. Based on this study's findings, fartlek training appears to not be beneficial to distance running performance until the peaking period.

CHAPTER VIII
Summary, Conclusions, and Recommendations

Summary

The scientific relationship between 10,000 meter performance and training methods remains incomplete. Researchers such as Slovic (1978) and Pollock (1977) have attempted to study the relationship between training practices of distance runners with the use of a survey. These studies, however, did not survey a variety of training methods across several phases of training. The phases or steps of training are known as periodization. Periodization is a a systematic approach to peaking an athlete for competition through a series of methodical stages. The purpose of this study was to evaluate the training methods of NCAA Division I runners with 10,000 meter performance. Fourteen Division I qualifying teams of the NCAA Division I national cross-country meet and 16 non-qualifiers were recruited through the mail and direct contact. The respondents completed a survey which evaluated the training methods of the respective teams during the transition phase, competition phase, and peaking period which encompassed seven months of training.

Statistical differences in the training methods of qualifying and non-qualifying teams were evident in the different phases. The statistical differences obtained are summarized as follows:

1. During the transition phase non-qualifying teams performed significantly longer runs.
2. During the competition phase qualifying teams ran significantly more miles.

Analysis of the qualifiers' training methods was performed to determine which training methods were related to performance at the national meet. The results of the correlations between team time and training methods are summarized as follows:

1. Significant positive correlations with team time were found for intervals, tempo, repetition, fartlek, and holding practice twice a day during the transition phase.
2. Significant positive correlations with team time were found for intervals, and fartlek training during the competition phase.
3. Significant negative correlations with team time were found for tempo and hill training during the peaking period.

Further analysis of the participating team finishing order and rank of the various training methods evaluated the relationship between training methods and performance of the teams. The results obtained from the analysis are summarized as follows:

1. Significant positive correlation for team rank was found for fartlek training and practicing twice a day during the transition phase.
2. Significant positive correlation for team rank was found for interval and fartlek training during the competition phase.
3. Significant negative correlation for team rank was found for interval training during the peaking period.

Significant training differences were evident between the top seven teams and lower seven qualifying teams. The differences in the training methods during the various phases are summarized as follows:

1. The lower seven qualifying teams used interval and fartlek training more often than the top seven qualifying teams during the competition phase. The top seven qualifying teams used repetition training significantly more often than the lower seven qualifying teams during the competition phase.

2. The top seven qualifying teams used fartlek training significantly more often than the lower seven qualifying teams during the peaking period.

Conclusions

Based on the results obtained from this study of the training methods of qualifying and non-qualifying teams of the 1996 Division I national cross-country meet, the following conclusions were made:

1. Tempos, repetition workouts, interval training, and fartlek training during the transition phase are significantly and positively related to team 10,000 meter performance time.
2. Interval training and fartleks during the competition phase are significantly and positively related to team 10,000 meter performance time.
3. Tempo during the peaking period was significantly and negatively related to team 10,000 meter performance time.

4. Lower seven qualifiers used more interval training, fartleks, and repetitions during the competition phase than the top seven qualifiers. The top seven qualifying teams used more fartlek training during the peaking period than the lower seven qualifying teams.
5. Non-qualifying teams had longer runs during the transition phase; less miles during the competition phase.
6. Teams that ranked lower at the national cross-country meet practiced twice a day more often, and using fartlek training more often during the transition phase than higher ranked teams; used interval training and fartlek more often during the competition phase; using less interval training during the peaking phase than the teams that ranked higher.
7. The use of various training methods can be used to accurately predict the mean team 10,000 meter finishing time in a group of Division I NCAA cross-country teams.

Recommendations

From the findings of this survey of the training methods of NCAA Division I cross-country runners on performance, several recommendations were made concerning further research on distance running:

1. Future studies should attempt to analyze differences that may exist between American and international training methods on performance characteristics.
2. A comparison of the training methods of the various collegiate divisions is needed to determine if similar training methods exist.

3. Further research is needed on repetition, tempo, and fartlek to determine the physiological benefits that may be gained by using these training methods to peak an athlete.

4. Further long term studies of the training of distance runners are needed to examine the unique physiological and performance contributions that various training methods provide. In particular the effect of various sequences and amounts of training methods on performance would be beneficial to understand the training of endurance athletes.

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APPENDIX A

November 18, 1996

Dear Coach ___________________:

The 22 year old American 10,000 meter record is 28 seconds slower than the current top Kenyan distance runner. The efforts of Todd Williams and Bob Kennedy at the international level have suggested that the talent is available in America. Much of previous research on the training principles of 10,000 meter runners has only evaluated the individual components of training and has neglected to evaluate the synergistic effects of various training methods. We are conducting a survey concerning the training procedures of the top American collegiate distance programs. By studying the training programs of the top athletes, we hope to improve our understanding of the requisites for successful performance. Therefore, we ask for your help by spending about 30 minutes completing the attached survey. By participating in the study you will receive the results of the study which will allow you to evaluate your training methods compared to other American coaches at the Division One level.

Because our purpose is establish a relationship between training methods and success, Jack Daniels, a well respected researcher and coach on distance running, has written a letter endorsing the study (see attached).

Your assistance is greatly appreciated. Please return the survey in the enclosed self-addressed, stamped envelope following the national cross-country meet as soon as possible. If you have any questions regarding the survey please do not hesitate to contact me at (402) 554-2670 or through e-mail at mkurz@cwis.unomaha.edu.

Sincerely,

Max Kurz
Masters of Science Candidate
University of Nebraska at Omaha

November, 1996

Dear Selected Coach:

This letter is written on behalf of Mr. Max Kurz, who is conducting a survey of successful Division I Cross Country Coaches, in an attempt to help determine what variables are associated with distance-running success.

Over the years, since I began my college coaching career (1961), I have been involved in many research projects ; often involving elite runners as subjects. I am particularly sensitive to the many demands that are placed on subjects in various research projects and appreciate the fact that coaches find little free time for answering questions, even if they concern the jobs that they perform on a daily basis. It's not the difficulty of the questions, it's just taking the time to sit down and get it done that causes most problems.

I'd like to encourage you to find the time as soon as possible, so that there is a good response in this matter. It usually works out best to get at these questionnaires when they first arrive so they don't get buried under a stack of letters to recruits, etc.

I have read over Max's materials and feel that he will come up with some good data and hopefully some useful feedback for the participants.

Again, let me encourage you to participate at your earliest convenience. Best of luck in the remainder of your current season.

Sincerely,

Jack Daniels, Ph. D.

APPENDIX B

Survey Directions

The following survey attempts to depict the overall training procedures that were utilized by your athletes in preparation for the 1996 national cross-country meet. The answer for each portion of the chart should correspond to the average of your whole team during the indicated time period. Although many of the questions pertain to training that has already occurred, please try to answer the questions to the best of your ability. For the questions on the following pages fill in the table with the appropriate number that corresponds to your team's training methods during the indicated time periods.

Because of the different interpretations of training methods by coaches, the terms used in the survey will be based on the following definitions:

Tempo runs - Distance run where the pace is 20 to 30 seconds slower than a runner's current 5,000 meter race pace. Purpose is to raise the lactate threshold of the runner.

Interval training- Repeated bouts of hard running at an intensity close to or faster than a runner's race pace followed by a recovery period lasting no longer than the time of hard running.

Repetition training- Repeated bouts of hard running (200 meters or more) that are run faster than a current 10,000 meter race pace. The recovery period that is long enough to allow for a full recovery. Repetition training differs from interval training in that it has a more complete recovery than interval training.

Hill training- Repeats at an 85 to 90 percent effort on a graded hill for 30 seconds to five minutes, with a recovery jog back down the hill.

Fartlek- Swedish word which means "speed play". Fartleks are done at various intensities and lengths with mixed periods of hard and easy running.

Cross training- A training session using an alternative mode of activity to running (e.g. cycling, swimming).

Drills- Supplementary training methods such as plyometrics, form drills, medicine ball drills, etc.

Rest- Avoidance of all vigorous physical ability, including running, weight lifting, jumping, cross training, etc.

Section A - Transition and Competition Phases

Fill in the following table with the appropriate number for the training phase. The answer for each portion of the chart should correspond to the average of your whole team during the indicated time period.

Training Method	May to August Transition Phase	September to October Competition Phase
Total miles run per week		
Longest run per week		
Total miles of race pace speed work		
Average number of days per week Involving:		
Tempo running		
Shorter easy running (other than warm-up and cool-down)		
Repetition Workouts		
Interval Training		
Hill Training		
Fartlek Training		
Cross Training		
Drills		
Weight training		
Rest		
Number of days per week that practice is held twice a day		

Section B - Peaking Period

Fill in the following table with the appropriate number for the training phase. The answer for each portion of the chart should correspond to the average of your whole team during the indicated time period.

Training Method	Oct 28 to Nov 3	Nov 4 to Nov 10	Nov 11 to Nov 17	Nov 18 to Nov 23
Total miles run per week				
Longest run per week				
Total miles of race pace speed work				
Number of days per week which involve:				
Tempo running				
Shorter easy running (other than warm-up and cool-down)				
Repetition Workouts				
Interval Training				
Hill Training				
Fartlek Training				
Cross Training				
Drill				
Weight training				
Rest				
Number of days per week that practice is held twice a day				

Briefly describe your philosophy of training distance runners. Please clarify any of the survey's training methods addressed as well as any other factors you consider important in training distance runners.