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TRAINING CHARACTERISTICS OF MALES AT THE 2008 NCAA DIVISION I CROSS COUNTRY CHAMPIONSHIPS

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TRAINING CHARACTERISTICS OF MALES AT THE 2008 NCAA DIVISION I CROSS COUNTRY CHAMPIONSHIPS

By

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Thesis

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Training Characteristics of Males at the 2008 NCAA Division I Cross Country Championships

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The focus of previous running research has been on physiological determinates of performance utilizing small sample sizes and short time frames with little regard to previous training methods. **PURPOSE:** The goal of this research was to describe, compare, and evaluate the relationships between anthropometric, run training, and ancillary training variables during the 2008 season and performance of male finishers at the NCAA Division I cross country championship 10k race. **METHODOLOGY:** An online survey was created based on previous research and all coaches who had male runners finish the 2008 NCAA championship race were asked to include their athletes in the online survey. 42 out of 252 runners (17%) completed the survey. **RESULTS:** Runners with better pre-college 1600 meter ($r = 0.37$) and 3200 meter ($r = 0.32$) track times ran faster at the championship race. A composite of these pre-college times was the best significant ($p < 0.05$) predictor of performance (adj. $r^2 = 0.12$). Stepwise multiple regression analysis showed an increased number of core training sessions during the peak period and form/drift sessions during the transition period also were significant ($p < 0.05$) predictors of slower 10k finish time. Threshold training during the peak period was a significant ($p <0.05$) predictor of 10k finish time (adj $r^2 = 0.07$) when compared only to run-training variables. Evidence of the training principles of progressive overload, periodization, specialization, and tapering were evident in the data. **CONCLUSION:** Recruiting faster runners is important for college coaches to have successful teams. Due to a low number of significant ($p < 0.05$) findings, there is no single best training method when training for the 10k race although excessive ancillary training can hinder rest and hurt run-training and race performance while threshold training during the peak period can lead to overtraining and slower performance times at the NCAA championship 10k race. Optimal performance in the NCAA cross country championship 10k race is dependent on coaches who can recruit faster runners and best integrate all training methods into each period and the entire season specific for his/her athletes.
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CHAPTER ONE: INTRODUCTION

Training programs of National Collegiate Athletic Association (NCAA) Division I mens cross country teams are drastically varied despite the fact that all teams have similar goals to run fastest at the end of the season. The important post-season competitions are regionals and, if qualified for, the NCAA Championships held in mid-November each year. These two meets are both 10 kilometer (10k) cross country races. Even though each runner strives to run fastest at these meets, coaches utilize many different training programs to achieve this similar goal.

There are many different components to a training program, but they can be broken down into three main categories for the purpose of this research.

1. **Endurance training** works to increase the pace a runner can hold over the distance of the race. This can be further sorted into mileage, long runs, and threshold training.

2. **Speed and strength training** is designed to allow the runner to run faster with a more economical running form therefore exerting less energy at a given pace. Types of speed and strength training include intervals, repetition, hill training, and fartlek training.

3. **Ancillary training** includes any exercise designed to improve performance that doesn’t specifically involve running. This involves cross training, weight training, form drills, plyometric drills, core strengthening and flexibility training.

A NCAA cross country coach must take all of these training components and put them into a specific workout plan while also considering the training history, age, and talents of the runners on the team.

The coach must also take into account the frequency, intensity and duration of each workout session when devising the season plan. He/she will push the runners to work hard at times but also allowing for rest and recovery at other times throughout entire season. Coaches utilize periodization, or dividing the season into phases which
place focus on different training methods. Most prominently, coaches will have runners build a base in the summer, slowly building up the volume of running. During the early and mid season periods, coaches will increase the intensity of the workouts. Towards the end of the season both volume and intensity of training are often decreased to allow the athlete full rest and recovery for the most important races.

Although very little research has been completed on current training methods (Karp, 2007; Kurz, Berg, Latin, & deGraw, 2000), many studies have been performed on the necessary physiological determinants of running performance (Billat, Demarle, Slawinski, Paiva, & Koralsztein, 2001; Craib, Mitchell, Fields, Cooper, Hopewell, & Morgan, 1996; Pate, Macera, Baily, Bartoli, & Powell, 1992; Acevedo & Goldfarb, 1989; Morgan, Baldini, Martin, & Kohrt, 1989; Berg, Olson, McKinney, Hofschire, Latin, & Bell, 1989). It is generally agreed upon that maximal oxygen uptake (VO$_{2\text{max}}$), running economy, the interaction between VO$_{2\text{max}}$, oxygen uptake kinetics, and lactate/ventilatory threshold are the four main physiological predictors of endurance performance (Jones & Carter, 2000).

- **VO$_{2\text{max}}$** associated with success in distance running (Costill, Thomason, & Roberts, 1973), is an individual’s maximal rate of aerobic energy expenditure and “limited by the rate at which oxygen can be supplied to the muscles (Jones & Carter, 2000).” Currently it is generally agreed that VO$_{2\text{max}}$ is a good predictor of performance when performance is greatly varied (i.e. recreational versus elite runners), but amongst runners with similar performance ability (elite versus elite runners), VO$_{2\text{max}}$ is not as good a predictor (Scrimgeour, Noakes, Adams, & Myburgh, 1986).

- **Running economy** is defined as the amount of oxygen required at a given absolute exercise intensity (Jones & Carter, 2000). One study concluded that highly trained runners with similar VO$_{2\text{max}}$ values had 10k performance times that were shown to be highly related to running economy (Conley & Krahenbuhl, 1980). Other studies have also shown that economy at selected speeds is highly

- The velocity at VO$_{2\text{max}}$ which involves both VO$_{2\text{max}}$ and exercise economy characteristics of an individual is oxygen uptake kinetics (Jones & Carter, 2000). It has been reported that faster running speed at VO$_{2\text{max}}$ is highly related with better 10k running performance (Morgan, Baldini, Martin, & Kohrt, 1989; Scrimgeour, Noakes, Adams, & Myburgh, 1986).

- Lactate/ventilatory threshold is defined as the running intensity “corresponding to the increase in blood lactate above resting levels (lactate threshold; LT) and the associated changes in gas exchange (ventilatory threshold; VT) (Jones & Carter, 2000).” Prolonged, moderate intensity training is regarded to best increase LT and VT as most research agrees that LT and VT improvements correlate well with performance improvements (Midgley, McNaughton, & Jones, 2007).

There are many other physiological determinants that have a smaller impact on an athlete’s overall performance. These components include flexibility (Hayes & Walker, 2007; Craib, Mitchell, Fields, Cooper, Hopewell, & Morgan, 1996), strength (Hickson, Dvorak, Gorostiaga, Kurowski, & Foster, 1988), power (Mikkola, Rusko, Nummela, Pollari, & Hakkinen, 2007; Sinnett, Berg, Latin, & Noble, 2001; Paavolainen, Hakkinen, Hamalainen, Nummela, & Rusko, 2003), and anthropometric characteristics (Coetzer, et al., 1996; Bale, Bradbury, & Colley, 1986). Coaches must determine how to integrate many components of training to improve physiological characteristics of the runners in order to produce the best possible performance.

**Statement of the Problem**

Coaches set a variety of training programs for their athletes to be successful at the end of the season. Cross country teams and runners that qualify for the NCAA Division I Championships are considered the best collegiate runners and it can be assumed that they are the most talented and best trained athletes. Amongst these
runners, what are the relationships connecting training methods and 10k race performance? The goal of this research was to summarize training methods of the faster NCAA cross country runners and determine the relationship of anthropometric variables, running history, and training methods to performance of male finishers at the 2008 NCAA Division I Cross Country Championships.

**Research Questions**

This paper intends to answer the following questions:

1. What are the training patterns amongst successful male NCAA cross country runners?
2. What is the relationship between age and performance at the 2008 NCAA Championship meet amongst male 10k finishers?
3. What is the relationship between academic year and performance at the 2008 NCAA Championship meet amongst male 10k finishers?
4. What is the relationship between height and performance at the 2008 NCAA Championship meet amongst male 10k finishers?
5. What is the relationship between weight and performance at the 2008 NCAA Championship meet amongst male 10k finishers?
6. What is the relationship between body mass index and performance at the 2008 NCAA Championship meet amongst male 10k finishers?
7. What is the relationship between number of years running and performance at the 2008 NCAA Championship meet amongst male 10k finishers?
8. What is the relationship between pre-college 1500/1600 meter personal best times and performance at the 2008 NCAA Championship meet amongst male 10k finishers?
9. What is the relationship between pre-college 3000/3200 meter personal best times and performance at the 2008 NCAA Championship meet amongst male 10k finishers?
10. What is the relationship between the **addition of pre-college 1500/1600 meter and 3000/3200 meter personal best times** and performance at the 2008 NCAA Championship meet amongst male 10k finishers?

11. What is the relationship between **weekly mileage** and performance at the 2008 NCAA Championship meet amongst male 10k finishers:
   a. During the summer period.
   b. During the transition period.
   c. During the competition period.
   d. During the peak period.
   e. During the entire season.

12. What is the relationship between **average number of runs per week** and performance at the 2008 NCAA Championship meet amongst male 10k finishers:
   a. During the summer period.
   b. During the transition period.
   c. During the competition period.
   d. During the peak period.
   e. During the entire season.

13. What is the relationship between **distance of the longest run** and performance at the 2008 NCAA Championship meet amongst male 10k finishers:
   a. During the summer period.
   b. During the transition period.
   c. During the competition period.
   d. During the peak period.
   e. During the entire season.

14. What is the relationship between **average weekly sessions of threshold training** and performance at the 2008 NCAA Championship meet amongst male 10k finishers:
   a. During the summer period.
   b. During the transition period.
   c. During the competition period.
15. What is the relationship between average weekly sessions of interval training and performance at the 2008 NCAA Championship meet amongst male 10k finishers:
   a. During the summer period.
   b. During the transition period.
   c. During the competition period.
   d. During the peak period.
   e. During the entire season.

16. What is the relationship between average weekly sessions of repetition training and performance at the 2008 NCAA Championship meet amongst male 10k finishers:
   a. During the summer period.
   b. During the transition period.
   c. During the competition period.
   d. During the peak period.
   e. During the entire season.

17. What is the relationship between average weekly sessions of fartlek training and performance at the 2008 NCAA Championship meet amongst male 10k finishers:
   a. During the summer period.
   b. During the transition period.
   c. During the competition period.
   d. During the peak period.
   e. During the entire season.

18. What is the relationship between average weekly sessions of hill training and performance at the 2008 NCAA Championship meet amongst male 10k finishers:
   a. During the summer period.
   b. During the transition period.
   c. During the competition period.
   d. During the peak period.
19. What is the relationship between **number of NCAA sanctioned races** and performance at the 2008 NCAA Championship meet amongst male 10k finishers:
   a. During the summer period.
   b. During the transition period.
   c. During the competition period.
   d. During the peak period.
   e. During the entire season.

20. What is the relationship between **average weekly sessions of cross training** and performance at the 2008 NCAA Championship meet amongst male 10k finishers:
   a. During the summer period.
   b. During the transition period.
   c. During the competition period.
   d. During the peak period.
   e. During the entire season.

21. What is the relationship between **average weekly sessions of strength training** and performance at the 2008 NCAA Championship meet amongst male 10k finishers:
   a. During the summer period.
   b. During the transition period.
   c. During the competition period.
   d. During the peak period.
   e. During the entire season.

22. What is the relationship between **average weekly number of drill and form training sessions per week** and performance at the 2008 NCAA Championship meet amongst male 10k finishers:
   a. During the summer period.
   b. During the transition period.
   c. During the competition period.
   d. During the peak period.
e. During the entire season.

23. What is the relationship between average weekly sessions of core training and performance at the 2008 NCAA Championship meet amongst male 10k finishers:
   a. During the summer period.
   b. During the transition period.
   c. During the competition period.
   d. During the peak period.
   e. During the entire season.

24. What is the relationship between minutes spent flexibility training per week and performance at the 2008 NCAA Championship meet amongst male 10k finishers:
   a. During the summer period.
   b. During the transition period.
   c. During the competition period.
   d. During the peak period.
   e. During the entire season.

25. What is the relationship between average weekly days of rest or without running, not due to injury, and performance at the 2008 NCAA Championship meet amongst male 10k finishers:
   a. During the summer period.
   b. During the transition period.
   c. During the competition period.
   d. During the peak period.
   e. During the entire season.

26. What is the relationship between days unable to run due to injury or illness and performance at the 2008 NCAA Championship meet amongst male 10k finishers:
   a. During the summer period.
   b. During the transition period.
   c. During the competition period.
   d. During the peak period.
e. During the entire season.

**Significance of the Study**

Gathering and comparing training methods data from high level collegiate runners could influence the way future runners and coaches set up training programs for 10k runners. Determining the relationship between race performance and training variables could indicate components that are more likely to produce better performances and therefore influence future training patterns. Relationships of anthropometric variables and running history to performance could influence how coaches recruit and develop runners. Lastly, because of the broad range of this research, currently overlooked components of training could be brought to light in this study indicating a need for further research.
Rationale of the Study

There has been much research on specific training components and their effect on the physiological markers of endurance (Craib, Mitchell, Fields, Cooper, Hopewell, & Morgan, 1996; Acevedo & Goldfarb, 1989; Morgan, Baldini, Martin, & Kohrt, 1989; Costill, Thomason, & Roberts, 1973) but very little recent research on training methods and performance in distance running (Kurz, Berg, Latin, & deGraw, 2000; Karp, 2007). Much of the past research has focused on endurance that has isolated one specific variable, gathered data for only a short period of time or was limited to a very small sample size. Although these studies have furthered the knowledge of human endurance, they only show a small piece of the entire training plan puzzle. Although there are a few survey based studies comparing training methods to performance (Karp, 2007; Kurz, Berg, Latin, & deGraw, 2000), it is an area that needs more focus.

Limitations

1. The results of this study hinged on athletes taking the time to fill out the online survey with complete honesty. They were reluctant to share training information as they do not want others to copy their program.
2. Four online surveys were incomplete while others may have been inflated, underreported, or with false data to keep the secrecy of training programs.
3. Due to the timing of the survey, many surveys may not have been completed due to availability during the holiday season.
4. The period to take the online survey did not start until completion of the 2008 NCAA Cross Country Championship; early season training information may have been forgotten or distorted.

Delimitations

1. This study is limited to subjects that can read English and be contacted through the internet, mail, or on the telephone.
2. All participants must have access to the internet to complete the online survey.
3. To be included in the results, subjects must have finished the 10k in the 2008 NCAA Cross Country Championships mens race.

4. Specific daily or weekly workouts will not be included; only averages of training data were gathered.

5. Motivational and psychological factors were not included in this study.

6. Facility, administrative support, altitude, and location information were not included.

Definition of Terms

The following definitions will be used in this paper:

10k Finish Time is the time it took the finishers to complete the 10 kilometer cross country course at the 2008 NCAA Cross Country Championships.

2008 NCAA Cross Country Championship Meet is held on November 24, 2008 in Terre Haute, Indiana. It is a 10k cross country race for the men and determines the final standing of teams and individuals for the 2008 NCAA cross country season.

Ancillary training includes any active training designed to improve performance that does not include running. This would include but not be limited to cross training, static stretching, weight training, speed/form drills, plyometrics, and core training.

Core training includes any training specifically designed to increase strength in the core region of a runner. This includes sit-ups, crunches, leg raises and isometric planks.

Cross training refers to any endurance training that is not running. This may include bicycling, swimming, pool running, Nordic skiing, or using an ellipse machine.

Fartlek is a Swedish term defined as “speed play” that indicates a type of interval training which combines varying speeds, times, and distances (Benyo & Henderson, 2002).

Finisher refers to the 252 male athletes that finished the 2008 NCAA Cross Country Championships 10k race. This is the total population of the study.
Flexibility training includes all types of stretching techniques. This includes ballistic stretching, passive stretching, contract-relax stretching, and static stretching (Noakes, 2003).

Hill training includes any training that involves the use of running up an incline or hill at a high intensity followed by rest periods.

Injury/Illness includes times when the runner was not able to perform at least 50% of the set running workout on that day.

Interval training refers to training designed to increase a person’s VO$_{2\text{max}}$ (Daniels, 2005). These are repeated bouts of hard running at intensity near race pace with a recovery period no longer than the running period (Kurz, Berg, Latin, & deGraw, 2000).

Long Run is the longest non-stop run a runner completes during the period or season. Daniels (2005) suggests that the weekly long run be 25 to 30% of total weekly mileage.

The marathon is a 26.2 mile (42.2 kilometers) race usually run on the road.

Mileage or miles per week refers to the total amount of distance, in miles, that an athlete runs in a given period of time. For the purpose of this study, the period of time will be set at one week or seven days.

Periodization is the process of dividing a training schedule into phases or periods for the purpose of peaking at the end of the season. For the purpose of this study, the season will be broken into four phases: summer (May and June), transition (July and August), competition (September and October) and peaking (November).

Qualifier is a term that will refer to the runners who meet the requirements to participate 2008 NCAA Cross Country Championship 10k race. In order to qualify for the meet, one must either qualify individually or be on a team that qualifies according the NCAA rules at a regional meet.

Races for the purpose of this research will only include cross country races that are during the NCAA season and are sanctioned by the NCAA.
Regional Meet refers to the nine separate meets that are used to qualify teams and individuals for the NCAA Cross Country Championship meet. These meets are a 10k race for men and held on November 15, 2008 at nine different sites. Teams and sites are determined by geographical location.

Repetition training is very fast running bouts followed by a full recovery whose purpose is to increase speed and economy of running (Daniels, 2005).

Rest is when a runner has a planned day with no physical training during the day, including running, cross training, and ancillary training.

A run is when an athlete takes sufficient amount of time running. A run may be of any time or distance, intensity, and outside, on a track, indoors, or on a treadmill, but the primary purpose is to move forward while running. For the purpose of this research, running while playing another sport (i.e. basketball, football, soccer, etc) does not count as a run.

Running economy is the energy needed to run at a given submaximal velocity and is measured as either sub-max VO2 or the respiratory exchange ratio (Saunders, Pyne, Telford, & Hawley, 2004).

Speed/Form drills and Plyometrics are designed to improve running form, efficiency, power, acceleration, and speed. They may include jumping, hopping and bounding movements designed to increase power (Dintiman, 2001).

Threshold or tempo training is used to increase endurance and stress the lactate-clearance capability (Daniels, 2005). Typically these workouts are run slightly slower than current race pace for the runner and of longer, steady running bouts (Daniels, 2005).

Weight training is training in a gym or weight room with the use of weights designed to increase strength and reduce injuries.
CHAPTER TWO: REVIEW OF RELATED LITERATURE

Distance running training plans have greatly evolved in the 70 years since the National Collegiate Athletic Association (NCAA) began hosting Division One cross country championships (Division I Cross Country History, 2008; Noakes, 2003). Today, coaches and runners can go to a book store and find a plethora of running books with detailed training plans for the 10 kilometer (10k) cross country race (Daniels, 2005; Beck, 2005; Noakes, 2003; Baeta & McKenzie, 1989; Costill D., 1979). This does not include the information that can be found in magazines or on the internet. Each book details a different training plan for the same race. *Lore of Running* (Noakes, 2003) even describes in detail the unique training plans of several elite distance runners from many different eras, including many of current elite runners. In general, coaches and runners can find much differing information on training for a 10k in the mass media.

Much of the past scientific research in human endurance has focused on a small number of training variables, had small sample sizes, or have looked at only physiological determinants (Billat, Demarle, Slawinski, Paiva, & Koralsztein, 2001; Jones A. M., 1998), while only a few studies have attempted to compile and compare longitudinal training data based on performance times for a large sample size of high level runners (Karp, 2007; Kurz, Berg, Latin, & deGraw, 2000). This review of literature will first examine studies that gathered training information from high level runners and then review each component of a typical training plan by looking at research centered specifically on that component. A critical examination of previous research will set the foundation for this performance based study of NCAA Division I Cross Country runners and illustrate how this research will build upon the strengths and improve upon the weaknesses of past studies.

Training Methods Research

There have been two quality studies done that have gathered training and performance data from a larger number of high level runners in the form of surveys with the goal of describing and comparing training methods (Karp, 2007; Kurz, Berg, Latin, &
deGraw, 2000). Kurz et al. (2000) compiled training data from 30 NCAA Division I cross country teams in 1996 with the goal of comparing mean team performance time to training methods. Karp (2007) sent surveys to the 2004 United States (US) Olympic Marathon Trials qualifiers to gather, describe and compare to performance. Both of these studies were similar in that they used surveys to gather training data after a major running competition but differed in what training variables were gathered and what race performance was compared.

In *Training Characteristics of Qualifiers for the U.S. Olympic Marathon Trials* by Jason R. Karp (2007) ninety-three high level US marathon runners responded to a questionnaire about physical and training methods. The US Olympic Marathon Trials are similar to the NCAA Cross Country Championships in that participants must qualify. For the 2004 U.S. marathon trials, male participants must have run under 2 hours and 22 minutes to qualify and female participants had a 2 hours and 48 minutes time to be eligible (Karp, 2007). The questionnaire that he sent to each qualifier asked for information on the following variables:
Physical Characteristics
- Age
- Height
- Weight

Training History
- Use of a coach
- Number of years training
- Use of altitude
- Weather athlete trains solo or with a group

Primary Source of Financial Support
- Full or part time job
- Spousal or parental support
- Corporate sponsorship
- Prize money

High School Performance Times
- 1 Mile
- 2 Miles

College Performance Times
- 1500m
- 3000m

Personal Best Times for Other Various Distances
- 5 km
- 10 km
- Half-marathon

Marathon Training Characteristics for the Whole Year
- Average weekly distance
- Peak weekly distance
- Longest training run
- Number of runs over 32 km
- Number of training days missed due to injury

Training Characteristics for Each Quarter of the Year
- Weekly distance at tempo pace
- Weekly distance at goal marathon pace
- Weekly distance at or faster than 10k race pace
- Weekly distance at or faster than 5k race pace
- Frequency of training
- Number of weekly interval workouts
- Number of strength workouts

(Karp, 2007)

Karp (2007) used this data and compared it to marathon personal best (PB) times.

Specifically looking at the running variables, he found that marathon PB was significantly correlated to 5k, 10k, half marathon, college 3000m performance for men \( r = 0.71, 0.73, 0.72, 0.58 \) respectively; \( p \leq 0.01 \) and women \( r = 0.68, 0.68, 0.73, 0.44 \) respectively; \( p \leq 0.01 \) (Karp, 2007). For only the women, marathon PB was significantly correlated to college 1500m performance, number of years training, average weekly distance, peak weekly distance and number of runs more than 32k (Karp, 2007). It is clear in Karp’s discussion section that he is surprised that his subjects do not run more mileage at faster paces (Karp, 2007). The men ran 75% and women ran 68% of their
training volume at low intensity (Karp, 2007). He concluded that runners placed highest importance on total volume and not on training intensity (Karp, 2007).

It was also surprising that there was generally a lack of significant relationships within training data for men in Karp’s study (2007). As indicated earlier, he did find correlations between PB times at shorter races and marathon PB but none between the training variables (Karp, 2007). This would seem to indicate that one single training variable is not more important than another; it is the combination of multiple training components that is responsible for performance in the marathon (Karp, 2007). Karp (2007) also makes note of the high variability in all of the training data collected that doesn’t allow for any division between faster and slower marathoners.

Although this research will utilize many of Karp’s methods, there are some flaws that will be improved upon. The obvious weakness is his lack of participation. Although 93 subjects are a high number of subjects, a response rate of 36.5% is low (Karp, 2007). Furthermore he only had 37 men and a larger number, 32, respondents being only of national class and not elite runners (Karp, 2007). When looking at his training data questions, he does ask many pertinent questions, but does not differentiate between some training methods. A runner could be doing interval training, repetition training, hill training, or fartlek training and in his study you would only know how many miles they ran at 10k or 5k race pace (Karp, 2007). Asking for this information may lead to correlations where Karp did not find any. Ancillary training is also neglected (Karp, 2007). Ancillary training methods have been proven in studies to be an effective tool when training to improve performance (Mikkola, Rusko, Nummela, Pollari, & Hakkinen, 2007; Paavolainen, Hakkinen, Hamalainen, Nummela, & Rusko, 2003; Flynn, Carroll, Hall, Bushman, Bronlinson, & Weidman, 1998; Foster, Hector, Welsh, Schrager, Green, & Snyder, 1995; Eyestone, 1994). This current study will improve upon these weaknesses by including a better differentiation between specific training methods and including many ancillary training options that coaches and runners have and currently use.

*The Relationship of Training Methods in NCAA Division I Cross-Country Runners and 10,000-Meter Performance* by Kurz, Berg, Latin, and deGraw (2000) is another study
that attempted to quantify and compare training and performance data of high level runners. This study set to generalize and compare training of 30 NCAA mens cross country teams in 1996 (Kurz, Berg, Latin, & deGraw, 2000). Although it was done well with some relevant conclusions, there were also weaknesses that could be improved upon.

Kurz et al. (2000) used the 1996 NCAA cross country results from the regional and national meet to determine subjects and performance. Surveys were sent to 22 mens qualifying teams and 22 randomly selected mens non-qualifying teams with 14 qualifying teams and 16 non-qualifying teams responding (Kurz, Berg, Latin, & deGraw, 2000). The cross country season training periods were set as the “transition phase (May to August), competition phase (August to October), and peaking period (November)” (Kurz, Berg, Latin, & deGraw, 2000). The survey asked for information on the following variables for each of the three phases:

- **Performance Data**
  - Team place at the NCAA Championship Cross Country Meet
  - Mean finish time of teams at the NCAA Championship Cross Country Meet

- **Mileage Data**
  - Total miles per week
  - Longest run per week

Coaches were to fill out the survey and mail them back for averaging and comparison. The data were compared between the qualifying teams and non-qualifying teams as well as the top seven and lower seven qualifying teams based on place at the NCAA Championship meet (Kurz, Berg, Latin, & deGraw, 2000).

Several significant differences were found. In the transition period, non-qualifying teams ran longer long runs than qualifying, 13.7±1.7 miles versus 11.5±2.1 miles.
miles (Kurz, Berg, Latin, & deGraw, 2000). Although not a significant difference, non qualifiers did run less per week than qualifiers in the transition phase, 62.7±10.6 versus 72.4±9.1 miles per week (Kurz, Berg, Latin, & deGraw, 2000). Between the qualifying teams, the lower seven teams used fartlek and interval training more often than the top seven teams. When looking for relationships to performance, it was found that in the transition phase, the mean time of qualifying teams was slower for teams that utilized thresholds training, repetitions, intervals, fartleks and two-a-day practices (Kurz, Berg, Latin, & deGraw, 2000). During the competition phase, times were slower at the NCAA Championship meet for teams that did intervals and fartlek training more (Kurz, Berg, Latin, & deGraw, 2000). Conversely, in the peaking period, teams that did threshold training ran faster at the NCAA Championship meet (Kurz, Berg, Latin, & deGraw, 2000).

Kurz et al. (2000) also did a Spearman rho to find correlations between finish order and the rank order of training methods. Using this statistical tool indicated that two-a-day practices and fartlek training during the transition phase and fartlek training and interval training during the competition phase correlated to a worse finishing place at the NCAA Championship meet (Kurz, Berg, Latin, & deGraw, 2000). Conversely teams that used hill training during the transition phase and intervals more often during the peaking period finished higher at the NCAA Championship meet (Kurz, Berg, Latin, & deGraw, 2000).

The Kurz et al. (2000) study is very similar to this research in many ways: use of the NCAA Cross Country Championship Meet to determine subjects and performance, use of a survey, and variables and definitions will be similar, but there will also be differences. The current study will focus more on the individual, realizing that even within one team, individual training plans may be drastically different. Also, a poor performance at the NCAA Championship meet by one runner may have hindered the overall team mean time (Kurz, Berg, Latin, & deGraw, 2000). Gathering data as the average number of days of use of per variable does not allow for a true understanding of the importance of an individual variable to a program. This research will ask instead how many miles or minutes per week the runner utilizes each variable. Interval training,
as an example, may be used 0.8 times per week during the competition phase but how many miles does this entail (Kurz, Berg, Latin, & deGraw, 2000)? There is a large difference between a 2 mile and a 5 mile interval workout, which in the Kurz et al. (2000) study both would have just signified that the training variable was used that week.

Lastly, the division into only three phases is not sufficient to gather accurate data (Kurz, Berg, Latin, & deGraw, 2000). The transition phase, which they determined to be the most important phase of the season, was by far the longest (Kurz, Berg, Latin, & deGraw, 2000). It could be deduced that the length of this phase, especially when compared to the other phases that were only two months and one month long, inherently makes this period the most important (Kurz, Berg, Latin, & deGraw, 2000). Another weakness with the periodization breakdown of the season that Kurz et al. (2000) used is that within the transition phase three of the four months were in the summer, May, June and July, when school and official practices are not in session and one month, August, when practice is just beginning. The current study will divide the season into four phases, with summer being May and June, transition including July and August, competition still being September and October, while November remains as the peaking phase. This will allow for the phases to be more properly distributed and reflect the actual periodization that is most prevalent in a collegiate cross country season. These improvements, utilizing individual data and not team data, gathering more specific volume data, and utilizing four phases will allow for more specific data that will allow for better comparison.

**Additional Studies that Gathered Training Data**

There have been several studies that have also tried to gather training data of competitive runners for the purposes of description and comparison. Many of these studies had small sample sizes, utilized a small time frame to collect training data, or both. These studies, though, have given insight into the training methods of high level runners that is valuable to coaches, runners, and the current research.
Superior fatigue resistance of elite black South African distance runners (Coetzer, et al., 1996) tried to determine why black runners were dominating white runners in South Africa, especially in the 10k (28 minutes( min) 33 seconds(sec) versus(vs) 29 min 38 sec; p < 0.005) and half-marathon (62 min 39 sec vs 67 min 19 sec; p < 0.0001)(see table 1). They found that although training volumes were similar, black runners (n = 9) reported running more of their total training volume at high intensities (>80% of VO2max) than their white counterparts (n = 11) (35.6±17.7% versus 13.5±7.1%; p<0.005) (Coetzer, et al., 1996). They also found that the black runners were shorter (168.9±5.1centimeters (cm) versus 181.3±3.0cm; p = 0.0006) and weighed less (56.0±5.4 kilograms(kg) versus 69.9±5.6 kg; p = 0.0004). This study, though, only utilized 20 runners and gathered training data of general total volume and percent of training at high intensity (>80% of VO2max) because the main focus was on physiological and nutritional data (Coetzer, et al., 1996).

<table>
<thead>
<tr>
<th>Table 1. Comparison of black and white South African variables.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Black (n = 9)</td>
</tr>
<tr>
<td>10k PR (min:sec)</td>
</tr>
<tr>
<td>Half Marathon PR (min:sec)</td>
</tr>
<tr>
<td>% Training &gt;80% of VO2max</td>
</tr>
<tr>
<td>Height (cm)</td>
</tr>
<tr>
<td>Weight (kg)</td>
</tr>
</tbody>
</table>

(Coetzer, et al., 1996)

Billat et al. (2003) looked at two different training philosophies amongst Kenyan elite runners. The high speed training group, of six runners, was characterized as running less weekly mileage with one or two weekly workouts at or faster than the velocity associated with VO2max (Billat, Lepretre, Heugan, Laurence, Salim, & Koralsztein, 2003). The low speed training group of seven runners ran more mileage, trained three times per day, utilized tempo training at the lactate threshold, and did no training at or faster than VO2max velocity (Billat, Lepretre, Heugan, Laurence, Salim, & Koralsztein, 2003). Both groups utilized longer interval training at a velocity between the lactate threshold pace and velocity associated with VO2max such as four intervals of 2000 meters...
(Billat, Lepretre, Heugan, Laurence, Salim, & Koralsztein, 2003). When comparing performance times at the 10k distance, the high speed group ran significantly faster than the low speed group (28 min15 sec±15 sec versus 28 min54 sec±33 sec; p = 0.003). Results also indicated that higher values of VO$_{2\text{max}}$ and velocity at VO$_{2\text{max}}$ were achieved by the high speed group (Billat, Lepretre, Heugan, Laurence, Salim, & Koralsztein, 2003). Despite these findings, this study only utilized 13 male runners and gathered only general training data for purposes of grouping the runners for comparison (Billat, Lepretre, Heugan, Laurence, Salim, & Koralsztein, 2003).

Bale et al. (1986) did a questionnaire of sixty 10k runners to collect and compare anthropometric and training variables. Respondents to the questionnaire were divided into three groups of twenty runners each based on personal best times in the 10k (Bale, Bradbury, & Colley, 1986). The elite group had run times under 29 min 30 sec while the good group’s times ranged from 30 min to 35 min and the average group was between 35 min and 45 min (Bale, Bradbury, & Colley, 1986). The elite runners weighed significantly less than the good and average runners (64.4±2.4 kg versus 66.3±5.0 kg versus 69.2±3.7 kg respectively; p < 0.05). The elite and average runners were significantly shorter than the good group (175.1±3.8 cm versus 173.5±9.5 cm versus 179.9±3.0 cm respectively; p < 0.05) (Bale, Bradbury, & Colley, 1986). Information on the following training variables were gathered:

- Number of Years Running
- Number of Miles Run per Week
- Number of Training Sessions per Week
- Long Steady Runs (% of Total Distance)
- Fast Runs (% of Total Distance)
- Interval Runs (% of Total Distance)
- Fartlek Runs (% of Total Distance)

(Bale, Bradbury, & Colley, 1986)

When looking at the elite runners, it was found that they had more years of running experience, ran more miles per week, and trained more often than the good and average runners (Bale, Bradbury, & Colley, 1986). This study only looked at a few training variables and converted them to percentage of total distance run per week,
which made them difficult to compare because each group had a different distance run per week (Bale, Bradbury, & Colley, 1986).

Lastly, a recent study done by Esteve-Lanao et al. (2005) looked at training methods of eight national class Spanish runners with the use of heart rate monitors. Esteve-Lanao et al. (2005) had runners use heart rate monitors for six months during training and tracked the amount of time runners spent in one of three training zones: light intensity (heart rate below the ventilatory threshold), moderate intensity (heart rate between the ventilatory threshold and respiratory compensation threshold), and high intensity (heart rate difference above the respiratory compensation threshold). These runners were trained in the low intensity zone for 71% of the time (Esteve-Lanao, San Juan, Earnest, Foster, & Lucia, 2005). This was found to highly correlate with race performance ($r = -0.79$ for 4.175k ($p = 0.06$) and $r = -0.97$ for 10.130k ($p = 0.008$)) (Esteve-Lanao, San Juan, Earnest, Foster, & Lucia, 2005). It was concluded that total training time at low intensities may be associated with better performance (Esteve-Lanao, San Juan, Earnest, Foster, & Lucia, 2005). This study, though, only looked at eight runners using heart rate zone data instead of specifically tracking training methods utilized.

Only a few studies have tried to gather and compare distance running training methods with performance of 10k or similar competitive runners (Karp, 2007; Esteve-Lanao, San Juan, Earnest, Foster, & Lucia, 2005; Billat, Lepretre, Heugan, Laurence, Salim, & Koralsztein, 2003; Kurz, Berg, Latin, & deGraw, 2000; Coetzer, et al., 1996; Bale, Bradbury, & Colley, 1986). Although these studies have provided meaningful results, they have only begun to scratch the surface of current training methods. This current research will collect and compare training data from a large number of high level runners for the purpose of comparison to performance.

For the remainder of this review of literature, each variable that is to be gathered with the questionnaire will be reviewed. Published research will be used to define, outline possible importance in a distance running training program, and give reasons for inclusion on the questionnaire.
Anthropometric Variables (Height, Weight, and B.M.I.)

Generally speaking, runners are light weight and of average height. Since many studies compare only elite runners that are of similar stature, it is difficult to decipher if there is an ideal height, weight, or body mass index (BMI) and research shows this.

Coetzer et al. (1996), when looking at differences between 11 black and nine white elite South African runners, found a significant difference between height and weight of the two groups. The black runners, who were deemed to be better runners due to personal best times in 1.65, 3, 5, 10, and 21.1 kilometer races were found to be shorter (168.9±5.1 vs 181.3±3.0 centimeters; p = 0.0006) and weigh less (56.0±5.4 vs 69.9±5.6 kilograms; p = 0.0004). Bale et al. (1986), compared anthropometric variables of 20 elite runners (personal best times < 29 min 30 sec), 20 good runners (personal best times between 30 and 35 min), and 20 average runners (personal best times between 35 and 45 min)(see table). The good runners were significantly taller than the elite and average runners (see table 2) (Bale, Bradbury, & Colley, 1986). The elite and good runners weighed less than the average runners while the elite runners had significantly less body fat than the two slower groups based on skinfold measurement and body fat percentage (Bale, Bradbury, & Colley, 1986). This lead to the conclusion that faster runners weigh less and are leaner than slower runners (Bale, Bradbury, & Colley, 1986).

<table>
<thead>
<tr>
<th>Variable</th>
<th>Elite Runners n = 20</th>
<th>Good Runners n = 20</th>
<th>Average Runners n = 20</th>
</tr>
</thead>
<tbody>
<tr>
<td>Height (cm)</td>
<td>175.1±3.8&lt;sup&gt;c&lt;/sup&gt;</td>
<td>179.9±3.0</td>
<td>173.5±9.5&lt;sup&gt;c&lt;/sup&gt;</td>
</tr>
<tr>
<td>Weight (kg)</td>
<td>64.4±2.4&lt;sup&gt;b&lt;/sup&gt;</td>
<td>66.3±5.0&lt;sup&gt;b&lt;/sup&gt;</td>
<td>69.2±3.7</td>
</tr>
<tr>
<td>Percent Fat</td>
<td>8.0±0.5</td>
<td>10.7±1.3&lt;sup&gt;ab&lt;/sup&gt;</td>
<td>12.1±1.5&lt;sup&gt;a&lt;/sup&gt;</td>
</tr>
<tr>
<td>Total of 5 skinfolds (mm)</td>
<td>24.6±1.0</td>
<td>29.4±3.5&lt;sup&gt;ab&lt;/sup&gt;</td>
<td>34.9±3.7&lt;sup&gt;a&lt;/sup&gt;</td>
</tr>
</tbody>
</table>

<sup>a</sup> significantly different from elite runners, p < 0.05  
<sup>b</sup> significantly different from average runners, p < 0.05  
<sup>c</sup> significantly different from good runners, p < 0.05  

(Bale, Bradbury, & Colley, 1986)
Billat et al. (2003) found no differences when comparing Kenyan runners that utilized different training philosophies. There was no significant differences between the height (170±4 versus 173±4 centimeters; p = 0.17) and weight (53.8±4.7 versus 56.7±3.7 kilograms; p = 0.28) of high speed runners and low speed/high volume runners. Billat et al. (2001) also found no differences when comparing differences between top class marathoners (personal best time of < 2hrs 11 min; n = 5) and high level marathoners (personal best time of < 2hrs 16 min; n = 5). The marathoner groups weighed 60.2±2.9 vs 59.3±2.5 kilograms (p = 0.53) and were 172±2 vs 172±2 centimeters tall (p = 0.75) respectively for the top class and high level male marathoners (Billat, Demarle, Slawinski, Paiva, & Koralsztein, 2001).

For the population of male NCAA Championship 10k qualifiers, many of the anthropometric variables may be similar. Since these are high level runners, research indicates that they will all weigh less and be leaner (Bale, Bradbury, & Colley, 1986; Coetzer, et al., 1996). This research will look if there is a relationship between the anthropometric variables of height, weight, and BMI to performance amongst NCAA Championship 10k qualifiers in 2008.

**Age, Year in College, and Number of Years of Distance Running Training**

The age, year in college, and running experience vary only slightly in the NCAA. Most collegiate runners are between the ages of 18 and 22, but there are some older runners who entered college later. It is usually assumed that older runners are more experienced and are better equipped to handle higher training loads. Only a very limited amount of research has found relationships between age and years of training and performance.

Bale et al. (1986), when comparing three groups of runners divided by 10k personal best time, found that the faster runners were non-significantly older than the two slower groups (28.1±3.0 vs 25.0±4.6 vs 26.3±7.5 years old; p > 0.05), but had been running for a significantly longer period of time (8.1±2.2 vs 5.2±2.2 vs 3.3±1.8 years; p <
Karp (2007) found no significant (p > 0.05) difference in male Olympic trials qualifiers in number of years training between the elite group and national class group of runners. The elite runners, though, had trained for an average of 5.4 years more than national class runners (16.8±3.6 vs 11.4±5.2 years) (Karp, 2007). This did show some practical difference between the two groups. Billat et al. (2001) found no relationship (p > 0.05) between age and performance between a two groups of high level marathon runners that were separated based on marathon time.

Very little research has explored how age, year in college, and years of distance running training effects performance. Generally, for the age range of this study, it is considered that older runners, who are over 20 years old, have an advantage over less experienced and less trained runners. Coaches, anecdotally, will slowly increase training of recruits and allow for the runner to develop physically, mentally and emotionally. This research will attempt to discover if this notion is correct.

Pre-College Personal Best Times

Athletes have to perform well before college to have the opportunity to participate in collegiate athletics. Coaches recruit the faster pre-college runners to their team, even offering scholarships to some. Other runners are allowed to “walk on,” or participate without a scholarship, but these runners often have to try-out and be accepted by the coach. Some research has shown that previous race times are highly related to current performance, even if the race distance is different.

When comparing previous personal best times in various distances amongst 37 male U.S. Olympic marathon trials qualifiers in 1996, Karp (2007) found many significant correlations to the marathon. Marathon best times were significantly (p ≤ 0.001) correlated to college 3000 m (r = 0.58), 5k (r = 0.71), 10k (r = 0.73), and half marathon (r = 0.72) personal best times (Karp, 2007). This shows that if a runner is talented, meaning he has run faster in the past, he is more likely to run faster in the future.
The question of pre-college personal best times could have an impact on recruiting in the NCAA. To be consistent, as cross country courses across the United States are varied, only track 1600m and 3200m times will be allowed, except from Oregon high school athletes, who run the 1500m and 3000m races in track. Most coaches believe that faster pre-college runners are more likely to be faster college runners, but amongst the best NCAA runners, is this still true?

Mileage

The question of how many miles to run in a given period of time has always been of utmost importance to runners. Running too many miles can lead to overtraining and an increased risk of injury while too few does not allow for optimal performance. Research has shown that running high mileage leads to more efficient running economy (Scrimgeour, Noakes, Adams, & Myburgh, 1986). Several studies have gathered data regarding mileage and its importance in training for endurance based events (Esteve-Lanao, San Juan, Earnest, Foster, & Lucia, 2005; Billat, Demarle, Slawinski, Paiva, & Koralsztein, 2001; Foster, Daines, Hector, Snyder, & Welsh, 1996; MacDougall, et al., 1992; Berg, Olson, McKinney, Hofschire, Latin, & Bell, 1989; Bale, Bradbury, & Colley, 1986; Scrimgeour, Noakes, Adams, & Myburgh, 1986).

Many studies have indicated that running higher mileage leads to improved performance (Esteve-Lanao, San Juan, Earnest, Foster, & Lucia, 2005; Billat, Demarle, Slawinski, Paiva, & Koralsztein, 2001; MacDougall, et al., 1992; Bale, Bradbury, & Colley, 1986). Bale et al. (1986) found that the faster male 10k runners, with personal best times of less than 29 min 30 sec, ran significantly more miles \((p < 0.05)\) than the two slower groups of runners, with personal best times between 30 min and 35 min and 35 min and 45 min, in their study. Results showed that the elite group averaged 67.8±6.2 miles per week while the good and average group only ran 57.5±7.5 and 38.1±13.2 miles per week respectively (Bale, Bradbury, & Colley, 1986). The correlation between 10k performance and mileage was also very high \((r = -.84)\) (Bale, Bradbury, & Colley, 1986).
Billat et al. (2001) found the same to be true for a group of 10 high level male marathon runners but not for 10 high level female marathon runners. Top class male marathon runners, with personal best times under 2 hours (hr) 11 min, averaged 128±16 miles per week, which was significantly more (p = 0.03) mileage than their slower counterparts, with personal best marathon times under 2 hr 17 min, who averaged 104±12 miles per week (Billat, Demarle, Slawinski, Paiva, & Koralsztein, 2001). For the females, top class runners who held personal best times under 2 hr and 32 min, ran 103±7 miles per week while slower marathon runners, with personal best times under 2hr and 36 min, ran 93±11 miles per week, which was not determined to be significantly different (p = 0.1). As illustrated in table 3, MacDougall et al. (1992) also found a strong correlation between weekly mileage and VO$_{2\text{max}}$, a physiological determinant of performance.

<table>
<thead>
<tr>
<th>Group</th>
<th>n</th>
<th>VO$_{2\text{max}}$ (ml*kg$^{-1}$*min$^{-1}$) (means±SD)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Controls (Sedentary)</td>
<td>22</td>
<td>42.5±1.6</td>
</tr>
<tr>
<td>5-10 miles/week</td>
<td>5</td>
<td>51.8±4.2</td>
</tr>
<tr>
<td>15-20 miles/week</td>
<td>11</td>
<td>54.5±2.6</td>
</tr>
<tr>
<td>25-30 miles/week</td>
<td>12</td>
<td>58.1±2.2</td>
</tr>
<tr>
<td>40-55 miles/week</td>
<td>9</td>
<td>62.9±3.7</td>
</tr>
<tr>
<td>60-75 miles/week</td>
<td>16</td>
<td>65.4±2.0</td>
</tr>
</tbody>
</table>

(MacDougall, et al., 1992)

A study by Scrimgeour et al. (1986) divided runners into three groups based on mileage. They found that that high mileage group ( > 62miles per week) had significantly (p < 0.05) faster performance times in races ranging from the 10k to the 90k than the two other groups that ran less mileage (Scrimgeour, Noakes, Adams, & Myburgh, 1986). This was suggested to be due to a better running economy that the high mileage runners had (Scrimgeour, Noakes, Adams, & Myburgh, 1986).

An interesting note about mileage is intensity of those miles. Although total miles run at various intensities (interval, fartlek, repetition, hills) will be collected in this
research, it is worthwhile to note overall intensity findings. Esteve-Lanao (2005) recently used heart rate monitors on eight national class Spanish runners. It was found that these runners spent a large majority of running time at light intensity (71%) which correlated highly with race performance ($r = -0.79$ for 4.175k ($p = 0.06$) and $r = -0.97$ for 10.130k ($p = 0.008$)) (Esteve-Lanao, San Juan, Earnest, Foster, & Lucia, 2005). These findings are in agreement with other studies that found that high level runners spend a majority of time, over 70%, at low running intensity (Billat, Demarle, Slawinski, Paiva, & Korsalsztein, 2001; Karp, 2007). These studies, though, only gathered training intensity based on recall and not direct heart rate data and therefore are not as strong (Billat, Demarle, Slawinski, Paiva, & Korsalsztein, 2001; Karp, 2007). It can be generally stated, though, that most runners train at low intensities for a majority of the training time (Karp, 2007; Esteve-Lanao, San Juan, Earnest, Foster, & Lucia, 2005; Billat, Demarle, Slawinski, Paiva, & Korsalsztein, 2001).

Berg et al. (1989) did a training study on one veteran runner. For eight weeks, the runner decreased his training mileage from 75.8 miles per week to 42.5 miles per week and increased the intensity by adding two interval workouts weekly (Berg, Olson, McKinney, Hofschire, Latin, & Bell, 1989). The runner actually decreased his 10k performance time by 10 sec although VO$_{2\text{max}}$ and running economy declined slightly (Berg, Olson, McKinney, Hofschire, Latin, & Bell, 1989). The main significance of the study was that performance can be maintained even with a large, over 50%, decrease in total training volume (Berg, Olson, McKinney, Hofschire, Latin, & Bell, 1989).

Other studies did not have any conclusions in regards to mileage (Kurz, Berg, Latin, & deGraw, 2000; Karp, 2007; Foster, Daines, Hector, Snyder, & Welsh, 1996). Kurz et al (2000) and Karp (2007) found no significant difference between faster and slower male runners weekly mileage. In women, Karp (2007) did find a moderate correlation to marathon personal best for average weekly distance ($r = -0.47$, $p=0.001$) and peak weekly distance ($r = -0.51$, $p < 0.001$). Foster et al. (1996) tracked 56 high level endurance athletes (runners, cyclists and speed skaters) for 12 weeks and also found no
significant correlations between changes in time trial performance and changes in training time ($r = -0.031$).

The research is very mixed on the subject of mileage. Some studies have reported that high mileage is related to faster performance times (Bale, Bradbury, & Colley, 1986; MacDougall, et al., 1992; Esteve-Lanao, San Juan, Earnest, Foster, & Lucia, 2005; Billat, Demarle, Slawinski, Paiva, & Koralsztein, 2001) while others reported no difference and very low relationships (Karp, 2007; Kurz, Berg, Latin, & deGraw, 2000; Foster, Daines, Hector, Snyder, & Welsh, 1996; Berg, Olson, McKinney, Hofschire, Latin, & Bell, 1989).

**Tempo/Threshold Training**

Tempo or threshold training is used to raise the lactate threshold and endurance by running at a pace slightly slower per mile slower than race pace (Daniels, 2005). These runs have become popular amongst coaches because they generally are regarded as easier on the body than repetition and interval training but still produce a good physiological and psychological response, as they act as a race simulation, just a little slower (Daniels, 2005). Training at the maximal lactate steady state (MLSS), defined as the running speed at which blood lactate concentration remains stable between 10 and 30 minutes of constant exercise, which is at a slightly higher intensity than lactate threshold pace, has been shown to increase time and distance to exhaustion (Philip, Macdonald, Carter, Watt, & Pringle, 2008; Billat, Sirvent, Lepretre, & Koralsztein, 2004).

Philip et al. (2008) did a training study that tried to determine the optimal method of training at the MLSS, which is at intensity just higher than lactate threshold. Fourteen runners took part in the training study for 12 weeks, with the first four weeks being base building (Philip, Macdonald, Carter, Watt, & Pringle, 2008). At week five, runners were randomly placed into either a continuous or intermittent group. The continuous group did eight weeks of training of longer (increasing from 21 to 33 min) runs at MLSS velocity. The interval group did eight weeks of 3 min repetitions $0.5 \text{ km}*\text{h}^{-1}$ above and below MLSS velocity (Philip, Macdonald, Carter, Watt, & Pringle, 2008). The
main finding was the both groups improved on many indicators of performance at the end of training, velocity at lactate threshold, running economy, VO$_{2\text{max}}$ and velocity at VO$_{2\text{max}}$, with the continuous group having slightly better improvements, but not significantly different (Philip, Macdonald, Carter, Watt, & Pringle, 2008). This study, though, does show that training at MLSS, which is just faster than lactate threshold pace, does improve determinants of performance (Philip, Macdonald, Carter, Watt, & Pringle, 2008) and was in agreement with Billat et al. (2004). Billat et al. (2004) had 11 male, veteran runners perform two workouts per week at MLSS velocity for six weeks and found small increases in VO$_{2\text{max}}$ ($p = 0.02$) and velocity at MLSS ($p < 0.01$) but large increases in time-to-exhaustion run at MLSS velocity ($44\pm10\text{ min and } 63\pm12\text{ min}; <0.01$). Both of these studies indicate that training at MLSS velocity, which is slightly faster that lactate threshold pace, increases endurance and has positive effects on determinants of performance.

Tempo running, at, or near lactate threshold pace has been shown to increase the lactate threshold (Philip, Macdonald, Carter, Watt, & Pringle, 2008; Billat, Sirvent, Lepretre, & Koralsztein, 2004) which is considered one of the four main physiological determinants of endurance (Jones & Carter, 2000). Karp (2007), despite collecting data on the use of tempo training by marathoners, found no consensus if its use was beneficial for performance. Esteve-Lanao et al. (2005), when looking at training zones based on heart rate data, also did not find an association between training at moderate and high intensities and performance times in 4.1 and 10.1 kilometer races. Kurtz et al. (2000) did find, though, that tempo training near the end of the season was related to improved performance. This current study will collect data on average miles per week of tempo training and determine if it is related to performance.

**Interval Training (VO$_{2\text{max}}$)**

Interval training is training designed to increase a person’s VO$_{2\text{max}}$ (Daniels, 2005). These are repeated bouts of hard running at intensity near race pace with a recovery period no longer than the running period (Kurz, Berg, Latin, & deGraw, 2000). There have been many interval studies which increase training through interval sessions
to determine if there are performance and/or determinants of performance changes (Billat, Flechet, Petit, Muriaux, & Koralsztein, 1999; Acevedo & Goldfarb, 1989). Most of these studies, though, have a small sample size and are for a short period of time, but they can show the effects a specific intervention can have on a runner’s performance and/or determinants of performance.

A study by Billat et al. (1999) on interval training and VO$_{2\text{max}}$ took eight highly trained subjects through four weeks of normal training with one interval session per week and four weeks of overtraining with three weekly interval sessions. Interval training was set as “five repetitions run at 50% of the time limit at $v$VO$_{2\text{max}}$ [velocity at VO$_{2\text{max}}$], with recovery of the same duration at 60% $v$VO$_{2\text{max}}$ (Billat, Flechet, Petit, Muriaux, & Koralsztein, 1999).” They found that after four weeks at normal training, the subjects velocity associated with VO$_{2\text{max}}$ ($p = 0.02$) and running economy ($p = 0.02$) improved but VO$_{2\text{max}}$, time to exhaustion at $v$VO$_{2\text{max}}$, performance, defined as distance run at $v$VO$_{2\text{max}}$, and lactate threshold were not significantly different ($p > 0.05$) (Billat, Flechet, Petit, Muriaux, & Koralsztein, 1999). After the overtraining weeks, neither performance nor any of the determinants of performance changed (Billat, Flechet, Petit, Muriaux, & Koralsztein, 1999). They concluded that one interval session at VO$_{2\text{max}}$ with one at the lactate threshold per week is sufficient to increase VO$_{2\text{max}}$ and $v$VO$_{2\text{max}}$ in runners while adding more interval training sessions may not positively or negatively affect performance (Billat, Flechet, Petit, Muriaux, & Koralsztein, 1999). Increased training did not increase any determinants of performance and increased some determinants of overtraining, such as self reports of fatigue, soreness, and sleep quality (Billat, Flechet, Petit, Muriaux, & Koralsztein, 1999).

Other studies that looked at interval workouts have had similar results. Acevedo and Goldfarb (1989) added interval and fartlek training onto seven competitive runners’ training for eight weeks. They observed significant ($p < 0.05$) improvement in 10k and run time to exhaustion performance. An additional conclusion was that performance increases can happen without increases to VO$_{2\text{max}}$ (Acevedo & Goldfarb, 1989). In the
study, subjects were able to run at a higher percent of VO$_{2\text{max}}$ before reaching the lactate threshold and therefore performed better (Acevedo & Goldfarb, 1989). Another study of one high level runner for 18 weeks concluded that multiple interval sessions per week enhanced running economy and VO$_{2\text{max}}$ more than just long endurance training (Conley, Krahenbuhl, & Burkett, 1981).

Kurz (2000) came to some significant conclusions in regards to interval training while Karp (2007) did not. In relation to interval training, the lower seven teams at the NCAA championship meet used interval training more often ($p < 0.01$) than the top seven did (Kurz, Berg, Latin, & deGraw, 2000). A Spearmon rho indicated that intervals utilized during the peaking period led to faster performances at the NCAA championships (Kurz, Berg, Latin, & deGraw, 2000). It was suggested that interval training used during the early months and racing portions of the season led to overtraining and possible injury, but this could not be verified within the scope of their study (Kurz, Berg, Latin, & deGraw, 2000).

This current study will collect data on the amount of miles that runners train utilizing intervals, which primarily are designed to increase VO$_{2\text{max}}$. Interval training is defined as intervals at or near race pace with recovery time no longer than the time of the interval (Kurz, Berg, Latin, & deGraw, 2000). Common interval distances include 800 meters, 1000 meters, 1 mile, and 2 mile and total distance of the interval sessions is often at or near race distance. With this information and results from the Billat et al. (1999) study, one would conclude that a successful runner would run approximately six miles of interval training per week when training for a 10k.

**Repetition (Speed) Training**

Repetition training, for the purpose of this study, is defined as running bouts at high intensity for short durations with enough rest between each repetition to allow for full recovery (Daniels, 2005). Repetition training differs from interval training in purpose and type. The purpose of repetition training is to increase speed, economy, running
mechanics, and anaerobic power while the main purpose of interval training is to increase VO$_{2\text{max}}$ (Daniels, 2005). Although in running, the terms ‘interval’ and ‘repetition’ are often interchanged, for the purpose of this research, interval training involves longer bouts of fast running with limited rest while repetition training entails shorter and faster running bouts with full recovery between bouts.

Helgerud et al. (2007) divided fifty-five active adults into four run-training groups to determine which type of training would improve select physiological characteristics over an eight week study. The training groups, which met three times per week during the study, were long slow distance running (45 min at 70% HR$_{\text{max}}$), lactate threshold running (24.25 min at 85% HR$_{\text{max}}$), 15/15 interval running (47 repetitions of 15s intervals at 90-95% HR$_{\text{max}}$ with 15s of active recovery), and four x 4 min interval running (four x 4 min intervals at 90-95% HR$_{\text{max}}$ with 3 min active recovery between intervals) (Helgerud, et al., 2007). The significant finding of this study was that the two high intensity groups significantly ($p < 0.05$) improved their VO$_{2\text{max}}$ when compared to the other groups (see table 1) (Helgerud, et al., 2007). Running economy (VO$_2$ at 7km*h$^{-1}$ at 5.3% inclination on a treadmill) was not different between any of the groups but did improve in all groups between 7.5 to 11.7% (Helgerud, et al., 2007). Lactate threshold did not improve when expressed at %VO$_{2\text{max}}$ but velocity at lactate threshold did significantly ($p < 0.001$) improve in all four groups (Helgerud, et al., 2007). This study illustrates that repetition training does have physiological benefits, mainly increasing VO$_{2\text{max}}$, which is beneficial for endurance runners (Helgerud, et al., 2007).

<table>
<thead>
<tr>
<th>Group</th>
<th>VO$_{2\text{max}}$</th>
<th>RE</th>
<th>LT (%VO$_{2\text{max}}$)</th>
<th>vLT</th>
</tr>
</thead>
<tbody>
<tr>
<td>Long Slow Distance</td>
<td>No Improvement</td>
<td>Improved</td>
<td>No Improvement</td>
<td>Improved **</td>
</tr>
<tr>
<td>Lactate Threshold</td>
<td>No Improvement</td>
<td>Improved</td>
<td>No Improvement</td>
<td>Improved **</td>
</tr>
<tr>
<td>15/15 Interval</td>
<td>Improved ***</td>
<td>Improved</td>
<td>No Improvement</td>
<td>Improved **</td>
</tr>
<tr>
<td>4 x 4 min Interval</td>
<td>Improved ***</td>
<td>Improved</td>
<td>No Improvement</td>
<td>Improved **</td>
</tr>
</tbody>
</table>

* $p < 0.05$; ** $p < 0.01$; *** $p < 0.001$

(Helgerud, et al., 2007)
These results are similar to other research on repetition training. Dawson et al. (1998) had nine healthy, fit but untrained males perform a mean of 16 sprint running training sessions over a time period of six weeks. The distance of the sprints varied from 30-80 meters, were performed at 90-100% maximum speed with 20-40 repetitions during each session, and extended rest for full recovery between sprints (Dawson, Fitzsimons, Green, Goodman, Carey, & Cole, 1998). They found that between pre and post tests, the runners significantly improved in two endurance based tests as well as sprint tests (see table 5). The supramaximal test was defined as the time it took the subject to run to exhaustion on a treadmill at 14 km * h\(^{-1}\) at a 20% gradient while the repeated sprint test (RST) was the time it took the runner to complete six 40 meter sprints with only 30 seconds of rest between repetitions (Dawson, Fitzsimons, Green, Goodman, Carey, & Cole, 1998).

<table>
<thead>
<tr>
<th>Variable</th>
<th>Pre-testing mean (SE)</th>
<th>Post-testing mean (SE)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Supramaximal run (sec)</td>
<td>49.9 (3.5)</td>
<td>55.5 (4.0)*</td>
</tr>
<tr>
<td>VO(<em>{2})(</em>{\text{max}}) (ml*kg(^{-1})*min(^{-1}))</td>
<td>57.0 (2.4)</td>
<td>60.5 (1.9)**</td>
</tr>
<tr>
<td>RST total time (sec)</td>
<td>35.66 (0.65)</td>
<td>34.88 (0.49) *</td>
</tr>
<tr>
<td>40 meter time (sec)</td>
<td>5.50 (0.05)</td>
<td>5.37 (0.08)**</td>
</tr>
</tbody>
</table>

* p < 0.05; ** p < 0.01  
(Dawson, Fitzsimons, Green, Goodman, Carey, & Cole, 1998)

They concluded that short repetition training does increase determinants of endurance running performance as well sprint ability (Dawson, Fitzsimons, Green, Goodman, Carey, & Cole, 1998).

This increase in speed is also related to better endurance performance. Sinnett et al. (2001) found a high positive correlation between 300 meter sprint times and 10k performance times amongst 20 trained male runners (r = 0.713; p ≤ 0.05). Due to this correlation and high correlations with two jumping tests to performance, it was concluded that anaerobic power is very important to distance running performance and
the addition of plyometric and speed training may be an important supplement to a 10k training plan (Sinnett, Berg, Latin, & Noble, 2001).

In Kurz et al. and Karp’s research, there were only limited findings on repetition training. Karp (2007) did not directly ask for information on repetition training, possibly due to limited use in marathon training. He asked for, instead, the number of weekly interval sessions and weekly distance at or faster than 5k pace but did not yeild any significant findings (Karp, 2007). Kurz et al. (2000), who used similar definitions of repetition training and interval training, found that repetition training during the transition phase, which was May through August, of a NCAA cross country season was associated with slower performance times at the NCAA Championship meet between the top seven and bottom teams ($r^2 = 28.1; p < 0.05$). They theorized that repetition training during the early season may be too demanding on the body and lead to fatigue later on in the season (Kurz, Berg, Latin, & deGraw, 2000). This current research will ask for the amount of miles of repetition training run per week during each of the four periods during the cross country season. Since this number will be low due to the physiological demand repetition training has on the body, small differences may be found between training programs and running performance levels.

**Hill Training**

Very little research has been done on the effects of hill training on distance running performance. Kurz et al. (2000) included hill training as a variable in his research, but no other studies that gathered data on distance running training gathered data on the use of hills during training. Hill running will be defined as training that includes repeated bouts of running uphill, with a set amount of rest in-between.

Early season hill training was related to faster team times amongst the 14 NCAA championship qualifiers when a multiple regression was performed in the study of NCAA cross country teams (Kurz, Berg, Latin, & deGraw, 2000). It was suggested that hill training may lead to power that relates more specifically to distance running performance, especially when compared to weight training (Kurz, Berg, Latin, & deGraw,
Also, hill training may be a form of high intensity training that has a lower chance of injury (Kurz, Berg, Latin, & deGraw, 2000).

Although very little research has been performed on hill training in relation to distance running performance, most teams do incorporate hill running into the overall training program. Kurz et al. (2000) found that hill training used during the early season may relate to faster times amongst NCAA Championship qualifying teams. This current research will collect data on the number of miles run per week doing hill training.

**Fartlek Training**

Fartlek training is a Swedish term that translates to mean “speed play” (Benyo & Henderson, 2002). It is defined as a type interval training of varying speeds, times, and distances (Benyo & Henderson, 2002). There are many types of fartlek workouts but common ones include ladders, where a runner increases the distance or time of the fast interval to a peak and then decrease back down, and light-pole runs, where a runner will run faster between light-poles, jog recovers, and then repeats. Generally, fartleks are often a combination of interval and repetition training where speed and recovery periods can vary in length and time.

In a study by Acevedo and Goldfarb (1989), seven competitive runners completed a training study that increased running intensity by adding three workouts a week to the runner’s normal training program. The extra workouts included a repetition, or VO\textsubscript{2max} workout and two fartlek runs covering 6-10 miles that included intervals near 10k race pace with a slow run pace between intervals allowing for minimum recovery (Acevedo & Goldfarb, 1989). These runners continued on their normal training of six runs of 5-12 miles each during the week (Acevedo & Goldfarb, 1989). Performance times in the 10k and a treadmill run to exhaustion test both significantly improved \((p < 0.05)\) (see table 6) after eight weeks of training (Acevedo & Goldfarb, 1989).
Table 6. 10k performance times and run time to exhaustion.

<table>
<thead>
<tr>
<th></th>
<th>10k Race Time (min:sec) (mean±SD)</th>
<th>Run Time to Exhaustion (min:sec) (mean±SD)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pre-Training</td>
<td>35:27±0:58</td>
<td>19:25±2:06</td>
</tr>
<tr>
<td>Post-Training</td>
<td>34:24±1:13*</td>
<td>23:18±2:28*</td>
</tr>
</tbody>
</table>

*Significant difference between pre- and post-training means; p < 0.05
(Acevedo & Goldfarb, 1989)

Again Karp (2007) found no significant conclusions to fartlek training but Kurz et al. (2000) did. Fartlek training during the transition and competition phases was associated with slower performance times (Kurz, Berg, Latin, & deGraw, 2000). This was hypothesized to be because fartlek training along with racing was too much for the runners, leading to overtraining and possible injury (Kurz, Berg, Latin, & deGraw, 2000). This hypothesis, though, could not be confirmed or denied due to the limited scope of the study. The current research will collect information on the number of miles per week of fartlek training, also collecting information on time missed due to injury, possibly determining the suggestion by Kurz that interval and fartlek training combined with racing may lead to overtraining and injury (Kurz, Berg, Latin, & deGraw, 2000).

Weekly Long Run

A common training element for distance runners is a long run. This is a single run that is usually run at a comfortable and easy pace. Although all programs vary, Daniels (2005) indicates that this run should be 25-30% of total weekly mileage. There is some conflicting research on long runs, indicating that shorter long runs may be better than longer long runs. This review of literature will be limited to research pertaining to 5k and 10k training only, as it would not be appropriate to compare long runs while training for these shorter distance races as opposed to marathons.

When comparing 14 qualifying teams with 16 non-qualifying teams for the 1996 NCAA championship mens cross country meet, Kurz et al. (2000) found that non-qualifying teams ran significantly longer weekly long runs than qualifying teams.
(13.7±1.7 miles vs 11.5±2.1 miles; p > 0.01) during the transition period of May, June, July and August. This indicates that running longer long runs early in the season may be difficult on the body and may lead to overtraining. Bale (1986), who researched sixty 10k runners, found that long steady runs of faster runners accounted for a less percentage of total weekly miles (p < 0.05)(see table 7). This is slightly misleading as the faster runners in Bale’s (1986) research also ran more weekly mileage, but the conclusion is still valid, the elite runners put less emphasis on long steady runs than slower runners.

Table 7. Mileage and % of long steady runs.

<table>
<thead>
<tr>
<th></th>
<th>Elite Runners n =20</th>
<th>Good Runners n = 20</th>
<th>Average Runners n = 20</th>
</tr>
</thead>
<tbody>
<tr>
<td>Miles per week</td>
<td>67.8±6.2</td>
<td>57.5±7.5&lt;sup&gt;ab&lt;/sup&gt;</td>
<td>38.1±13.2&lt;sup&gt;a&lt;/sup&gt;</td>
</tr>
<tr>
<td>Long Steady Runs (% of total Distance)</td>
<td>59.5±10.0</td>
<td>76.5±8.3&lt;sup&gt;ab&lt;/sup&gt;</td>
<td>87.0±12.9&lt;sup&gt;a&lt;/sup&gt;</td>
</tr>
</tbody>
</table>

<sup>a</sup> significantly different from elite runners, p < 0.05  
<sup>b</sup> significantly different from average runners, p < 0.05  
<sup>c</sup> significantly different from good runners, p < 0.05  

(Bale, Bradbury, & Colley, 1986)

Although little research has been gathered on the relationship between the distance of the long run and performance, it is still a training method used by most runners. Too long of a long run may lead to overtraining but too short of a long run may not lead to the physiological adaptations necessary for high level performance (Kurz, Berg, Latin, & deGraw, 2000; Bale, Bradbury, & Colley, 1986). This research will try to indicate if there is a relationship between performance and the distance of the long run during each of the four periods and the entire season.

**Cross Training**

With the high workloads that runners are now enduring while training, some integrate cross training into the overall program to limit some of the detrimental effects running has on the body. Also, cross training can be a method to maintain fitness during periods of injury. Cross training can include, but is not limited to, bicycling, swimming,
water-running, cross country skiing, and use of fitness club machines such as stationary bicycles and elliptical trainers. Often times, there are two reasons for the use of cross training: 1) the runner is injured and cannot run but can cross train to maintain fitness or 2) the runner’s volume of running is high and risk of injury is lowered if some of the running miles are substituted with cross training.

Several studies have shown that cross training creates similar physiological responses and can lead to similar performance (Kurz, Berg, Latin, & deGraw, 2000; Flynn, Carroll, Hall, Bushman, Bronlinson, & Weidman, 1998; Gehring, Keller, & Brehm, 1997; Eyestone, 1994; Mutton, Loy, Rogers, Holland, Vincent, & Heng, 1993). Competitive runners have been found to be able to maintain similar intensities to running on land while water-running (with or without a flotation vest) (Gehring, Keller, & Brehm, 1997). Eyestone (1994) divided 32 trained subjects into either a running, cycling or water-running group and had them follow similar training programs when comparing frequency, duration, and intensity with the modality being the only difference. After the six week period, there were no significant (p < 0.05) post test differences in change of VO$_{2\text{max}}$ and two mile run times indicating that performance and determinants of performance can be maintained by both cross training methods (Eyestone, 1994). Flynn et al. (1998) divided 20 well trained runners into a cross train group or a run only group. Both groups continued their normal running programs but reported for three additional workouts (Flynn, Carroll, Hall, Bushman, Bronlinson, & Weidman, 1998). The two groups did similar workloads in the extra workouts, based on VO$_{2\text{max}}$, but the cross train group worked on a bicycle ergometer while the run only group ran on a track (Flynn, Carroll, Hall, Bushman, Bronlinson, & Weidman, 1998). Both groups improved at a similar rate in a five kilometer performance test at the end of the six weeks (Flynn, Carroll, Hall, Bushman, Bronlinson, & Weidman, 1998). A similar study, that involved two small training groups (run only (N = 6) and cycle/run (N=5)), found similar results in that both training modes significantly (p < 0.05) improved aerobic capacity (VO$_{2\text{max}}$ and submax treadmill tests) and run performance (5 kilometer and 1609 meter simulated races) (Mutton, Loy, Rogers, Holland, Vincent, & Heng, 1993).
Lastly, in the Kurz et al. (2000) study of NCAA cross country teams in 1996, qualifying teams for the NCAA championship meet used cross training more often than those that did not qualify during the transition phase (May, June, July and August) showing that cross training may be of benefit to collegiate runners building a base for the upcoming season.

Other studies have shown that cross training does not allow for increased performance when compared to running specific training (Foster, Hector, Welsh, Schrager, Green, & Snyder, 1995; Walker, White, & Wells, 1993). Foster et al. (1995) divided 30 well-trained runners (10 men and 20 women) into either a 10% increased running group, 10% increased swimming, or baseline group for eight weeks. The purpose was to increase training for two groups of runners but with different modalities and also have a control group (Foster, Hector, Welsh, Schrager, Green, & Snyder, 1995). The findings were that while both increased training (swimming and running) groups improved on a 3.2 kilometer time trial and the control group did not, the running group increased more (Foster, Hector, Welsh, Schrager, Green, & Snyder, 1995). Foster et al. (1995) concluded that specific training is best to improve performance the most. Another study that compared runners to triathletes and duathletes also had a similar conclusion (Walker, White, & Wells, 1993). The runners in the study ran more miles (86±18 versus 34±6 miles; p ≤ 0.001) but trained less overall time (8.5±2 versus 18±3 hrs; p ≤ 0.001) than the triathletes and duathletes because of the added modalities of training (Walker, White, & Wells, 1993). With these training disparities, the runners had just a slightly better VO2max (p > 0.05), running economy (p >0.05), but significantly better 10k personal best time (p ≤ 0.05) (Walker, White, & Wells, 1993). Both these studies show that although cross training can be an effective means to maintain or even increase running performance, specific run training is probably best (Foster, Hector, Welsh, Schrager, Green, & Snyder, 1995; Walker, White, & Wells, 1993).

Cross training can be used to increase training volume with a reduced risk of injury. Studies have shown that for a limited amount of time, performance and
Determinants of performance can be maintained (Kurz, Berg, Latin, & deGraw, 2000; Flynn, Carroll, Hall, Bushman, Bronlinson, & Weidman, 1998; Gehring, Keller, & Brehm, 1997; Eyestone, 1994; Mutton, Loy, Rogers, Holland, Vincent, & Heng, 1993) while other studies have shown that specific run training is best to improve run performance (Foster, Hector, Welsh, Schrager, Green, & Snyder, 1995; Walker, White, & Wells, 1993).

It will be interesting to learn if runners in the study utilize cross training and if there is a positive relationship between it and performance.

**Flexibility**

Stretching is a controversial subject for runners (Hayes & Walker, 2007). Historically inflexibility has been viewed as risk factor for injury, but recently studies have shown that increased flexibility may be a detriment to performance and some inflexibility may lead to better performance (Jones A. M., 2002; Craib, Mitchell, Fields, Cooper, Hopewell, & Morgan, 1996). Other studies have shown that pre-exercise stretching has no effect on determinants of performance (Hayes & Walker, 2007; Nelson, Kokkonen, Eldredge, Cornwell, & Glickman-Weiss, 2001) but also has not been shown to reduce risk of injury (Pope, Herbert, Kirwan, & Graham, 2000).

Craib et al. (1996) determined that inflexibility in dorsiflexion ($r = 0.65$) and standing hip rotation ($r = 0.53$) are significantly ($p \leq 0.05$) related to running economy in a group of 19 high level distance runners. In a correlation between the sit and reach test and running economy of 34 high level male distance runners, Jones (2002) found a highly significant relationship ($r = 0.68; p < 0.0001$), meaning the less flexible a subject was, the more economical as well. These two studies show that a certain amount of inflexibility may be beneficial to distance running performance and therefore a large amount of stretching may be detrimental (Jones A. M., 2002; Craib, Mitchell, Fields, Cooper, Hopewell, & Morgan, 1996).

Hayes and Walker (2007) had seven competitive male distance runners complete four different pre-exercise stretching routines (one of the four were control) before
running economy and steady-state oxygen uptake tests. Each of the stretching routines increased flexibility (p = 0.008) but had no effect on running economy (p = 0.915) or steady-state VO₂ (p = 0.943) (Hayes & Walker, 2007). Another study of 16 male and 16 female recreational runners had an experimental group and a control group with 16 in each group and an equal distribution of the sexes (Nelson, Kokkonen, Eldredge, Cornwell, & Glickman-Weiss, 2001). Both groups continued normal running training, but the experimental group added 40 min of 15 different lower limb static stretches three days per week for 10 weeks (Nelson, Kokkonen, Eldredge, Cornwell, & Glickman-Weiss, 2001). The experimental group improved significantly more than the control group in the sit and reach test (3.1±2.2 centimeters; p <0.05) but neither group showed any significant (p > 0.05) changes in O₂ cost for a sub-maximal run (Nelson, Kokkonen, Eldredge, Cornwell, & Glickman-Weiss, 2001). Both of these studies concluded that pre-exercise stretching has no effect on specific determinants of performance.

The research may be inconclusive of its benefits to determinants of performance, but many runners still stretch because it is believed improved flexibility will reduce the risk of injury. In a study by Pope et al. (2000) on 1538 Australian army recruits that were randomly assigned into either a stretching or control group, the injury risk was not significantly different (p > 0.05) between the groups. This was the only study found that examined injury risk on a large scale. Its conclusion, though, is that stretching does not reduce the risk of injury (Pope, Herbert, Kirwan, & Graham, 2000).

When observing runners, most will casually stretch before and/or after running, but is it worthwhile? As noted, the research is conflicting as some studies have shown flexibility can be a detriment to performance and determinants of performance while others have shown that flexibility has no effect (Hayes & Walker, 2007; Jones A. M., 2002; Nelson, Kokkonen, Eldredge, Cornwell, & Glickman-Weiss, 2001; Craib, Mitchell, Fields, Cooper, Hopewell, & Morgan, 1996). The only study found on stretching and injury risk concluded that there was no difference between a stretching and a control
group (Pope, Herbert, Kirwan, & Graham, 2000). This research looks to examine how much time distance runners spend time on improving flexibility.

**Weight Training**

Weight training can be utilized to improve performance as well as prevent injuries. For the purpose of this study, weight training will be defined as exercises that are designed to increase the capacity to perform high-intensity and high-resistance exercise of a few repetitions (Hickson, Dvorak, Gorostiaga, Kurowski, & Foster, 1988). Weight training will only include training for strength, as opposed to power, because power training is more appropriate within the form drills and plyometrics variable. The research by Karp (2007) and Kurz et al. (2000) both gathered information about the use of weight training by competitive distance runners and only one study was found that looked at strength training and running performance amongst trained distance runners (Hickson, Dvorak, Gorostiaga, Kurowski, & Foster, 1988).

Hickson et al. (1988) compared performance before and after the addition of a three day per week weight training program for 10 weeks. The eight well trained cyclists and runners added the weight training program and kept endurance training constant during the experiment (Hickson, Dvorak, Gorostiaga, Kurowski, & Foster, 1988). Results found that leg strength increased by 30% without any increases in body size. For endurance performance results, VO2max and 10k run times were unchanged but cycling to exhaustion and short term endurance of four to eight minutes were shown to be improved (p < 0.05) (Hickson, Dvorak, Gorostiaga, Kurowski, & Foster, 1988). These results indicated that some endurance performances can be improved through weight training (Hickson, Dvorak, Gorostiaga, Kurowski, & Foster, 1988).

Neither Karp (2007) nor Kurz et al. (2000) found any conclusive evidence regarding weight training. Karp (2007), although information was collected, did not report on strength training information while Kurz et al. (2000) reported that the NCAA cross country championship qualifiers did utilize weight training from zero to four days.
per week but found no correlation to performance leaving the research on weight training and performance in distance running to be lacking. This research will ask on the use of weight training. Possibly a relationship will be found between running performance and the use of weight training.

**Speed/Form Drills and Plyometrics**

These two seemingly different supplemental training variables are actually very similar for runners. Plyometrics and form drills are exercises used in conjunction with endurance training that are designed to improve running form and power, which is the body’s ability to produce a large amount of energy in a short period of time. These drills include, but are not limited to, jumping, skipping, shuffling, and bounding exercises.

Sinnett et al. (2001), when comparing 20 male trained runners found that two jumping tests correlated highly with 10k run performance. The vertical jump test, where the subject was allowed to use a countermovement, had a correlation of -0.393 ($p \leq 0.05$) and a triple jump test from a motionless start had an even higher correlation of -0.778 ($p \leq 0.05$) (Sinnett, Berg, Latin, & Noble, 2001). The researchers concluded that power and speed development may be beneficial to distance runners (Sinnett, Berg, Latin, & Noble, 2001).

Paavolainen et al. (2003) performed a controlled study on 22 trained runners to determine if plyometric training could improve running performance in a 5k. Twelve randomly selected subjects replaced 32% of their running hours with plyometric training, while ten others served as a control group (Paavolainen, Hakkinen, Hamalainen, Nummela, & Rusko, 2003). The plyometric training consisted of sprint repetitions of 20 to 100 meters and jumping exercises of “alternative jumps, bilateral countermovement, drop and hurdle jumps, and one legged, five jump tests” without added weight (Paavolainen, Hakkinen, Hamalainen, Nummela, & Rusko, 2003). They found that the subjects 5k run time, running economy, and peak velocity on the maximal anaerobic running test were significantly better in the experimental group and
not in the control group (Paavolainen, Hakkinen, Hamalainen, Nummela, & Rusko, 2003). In a controlled, random assignment study by Turner et al. (2003), plyometric training over an 8 week period was found to improve running economy at all three velocities tested on a level treadmill (p < 0.05). Both studies concluded that explosive-strength training, in conjunction with endurance training can elicit improvements in 5k run performance and running economy (Paavolainen, Hakkinen, Hamalainen, Nummela, & Rusko, 2003; Turner, Owings, & Schwane, 2003).

In a similar study, Mikkola et al. (2007) replaced 20% of endurance training of young (17.3±0.9 years old) distance runners with explosive type strength training of sprinting, jumping and strength exercises that emphasized low loads with high action velocities. They found that the experimental group had improved anaerobic and selective neuromuscular performance characteristics without decreases in aerobic characteristics when compared to pre-test and control group results (Mikkola, Rusko, Nummela, Pollari, & Hakkinen, 2007). The results confirmed the findings of Paavolainen et al. (2003).

The use of plyometric training and speed/form drills can be beneficial to distance runners (Mikkola, Rusko, Nummela, Pollari, & Hakkinen, 2007; Paavolainen, Hakkinen, Hamalainen, Nummela, & Rusko, 2003; Sinnett, Berg, Latin, & Noble, 2001). These are drills that include sprints, jumps, bounding, and skipping used to supplement a distance running training program. This research will ask on the amount of use of plyometric training to see if there is a relationship to performance.

Core Strength Training

Many runners can be seen performing crunches, sit-ups, isometric planks, and back extension exercises in order to strengthen core muscles and improve performance. Although little scientific research has been done on this subject (Stanton, Reaburn, & Humphries, 2004) there is much anecdotal evidence in popular running magazines, books, and internet sources.
Stanton et al. (2004) did a six week study to determine if core strengthening on a Swiss ball increases core stability and/or running economy. Eighteen subjects were divided into control (n = 10) and experimental (n = 8) groups. The experimental group performed two Swiss ball training sessions twice per week for the six week period. Each session consisted of six exercises. After training it was concluded that although core strength was stronger in the experimental group, there were no differences in VO_{2max} values, running economy, and running posture in either group.

Although core training may be done by most runners, it is inconclusive if its adaption into a running training program is beneficial to performance. Data was collected on the number of core strengthening sessions per week in each of the four periods to determine if there is a relationship between core training and performance.

Rest -- no running/physical activity (not due to injury)

It is generally known amongst coaches and runners that rest is a very important component of training. If a runner trains too often and with too much effort, he is risking overtraining. Too much rest, though, will not lead to optimal performance. Only one longitudinal training methods study was found that included rest as a variable.

Kurz et al. (2000) found that during the transition phase, May, June, July, and August, teams that had qualified for the NCAA championships had more days without running than teams that did not qualify in the study. The transition phase is six months to two months before the goal race of NCAA regionals and NCAA Championships (Kurz, Berg, Latin, & deGraw, 2000). This indicates that some rest early in training can be beneficial as it may allow the body to recover from the previous season and prepare it for the next (Kurz, Berg, Latin, & deGraw, 2000).

Very little research has been found on the variable of rest in distance running training. It is well known that one must rest and recover from intense training to avoid overtraining and breakdown of the body. This research will attempt to determine if there is a relationship between rest and performance.
**Average # runs per week**

The number of times a runners runs per week affects mileage. Often times, high level runners will run twice in a day, with one run being a shorter run and another being a long run or workout. Several studies have asked for number of runs completed per week with the intent of comparison to performance (Kurz, Berg, Latin, & deGraw, 2000; Karp, 2007; Bale, Bradbury, & Colley, 1986)

The Kurz et al. (2000) study of 1996 NCAA cross country teams found that practice held twice a day led to slower times amongst the 14 qualifying teams. A significant positive correlation was found between mean team time at the NCAA Championship meet and practice held twice a day during the transition phase (May, June, July, August) indicating that this variable was associated to slower performances ($R^2 \times 100 = 39.7; p \leq 0.05$). Also a Spearmon rho confirmed that practice held twice a day during the transition phase related to a lower finishing place ($R^2 \times 100 = 31.4; p \leq 0.05$).

Bale et al. (1986), when comparing training variables between three groups of runners separated by 10k times, found that the elite runners, with personal best times under 29 min 30 sec, trained more often than the good group, with times between 30 and 35 min, and the average group, than runs between 35 and 45 min for a 10k (10.7±1.2 versus 7.3±1.1 versus 4.8±1.4 sessions per week; p < 0.05).

**Injury and Illness**

Running injuries can happen for many reasons. Common culprits include overtraining, shoes, terrain, biomechanical deficiencies, and just plain bad luck, but basically occur when stress and frequency of stress do not allow for proper recovery (Brunet, Cook, Brinker, & Dickinson, 1990). Running injuries, for the purpose of this study, will be defined as injuries that prevented the runner from running or fully participating in planned running workouts, whether or not medical treatment was necessary (Van Mechelen, Twisk, Molendijk, Blom, Snel, & Kemper, 1996). While
performance can be somewhat maintained during decreased training periods with the use of cross training methods, cross training is not as desirable as specific run training performance (Eyestone, 1994; Flynn, Carroll, Hall, Bushman, Bronlinson, & Weidman, 1998; Gehring, Keller, & Brehm, 1997; Mutton, Loy, Rogers, Holland, Vincent, & Heng, 1993; Walker, White, & Wells, 1993; Foster, Hector, Welsh, Schrager, Green, & Snyder, 1995).

Races

Although not researched at all previously, races are definitely a part of the overall training program for runners. Coaches carefully select the timing and number of races so they fit with the overall training schedule for the runners. No previous research was found involving the number of competitions and performance at the end of the season, it is important to include this variable in the research. Racing too often could be a detriment to performance as it may lead to overtraining or have an impact on the overall training plan. A runner may not have enough experience racing and be at a disadvantage at the important meets at the end of the season if too few of races are performed. This research will ask the number of NCAA sanctioned races an athlete competes in to determine if there is a relationship to performance.
CHAPTER THREE: METHODOLOGY

The 2008 NCAA Cross Country Championship 10k mens race finishers were surveyed to determine which, if any, training variables significantly relate to better performance. This chapter will review the procedures and methods that were used in this project. This includes the design of the survey instrument, the subject recruitment, distribution, and collection of the survey, organization and analysis of the data.

Design of the Survey Instrument

Designing the survey instrument is important to meet the stated goals of this research. First previous research was used to select the variables that have been found to be the most pertinent to 10k runners. Specifically the research by Karp (2007) and Kurz et al. (2000) were used to select possible variables that need inclusion. A list of possible variables was derived following analysis of these and other studies (Karp, 2007; Kurz, Berg, Latin, & deGraw, 2000; Billat, Demarle, Slawinski, Paiva, & Koralsztein, 2001; Billat, Lepretre, Heugan, Laurence, Salim, & Koralsztein, 2003; Bale, Bradbury, & Colley, 1986; Coetzer, et al., 1996). After discussion with other runners and the thesis committee, the survey variables were finally narrowed down and selected (see table 8)
### Table 8. Variables to be collected.

<table>
<thead>
<tr>
<th>Dependent Variables</th>
</tr>
</thead>
<tbody>
<tr>
<td>Place at 2008 NCAA Championships</td>
</tr>
<tr>
<td>Time at 2008 NCAA Championships</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Anthropometric Variables</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age at time of race</td>
</tr>
<tr>
<td>Year in College</td>
</tr>
<tr>
<td>Height</td>
</tr>
<tr>
<td>Weight</td>
</tr>
<tr>
<td>Body Mass Index (BMI)</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Previous Racing Variables</th>
</tr>
</thead>
<tbody>
<tr>
<td># years of competitive running</td>
</tr>
<tr>
<td>Pre-College Track 1500 or 1600m PR</td>
</tr>
<tr>
<td>Pre-College Track 3000 or 3200m PR</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Training Variables</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mileage per week</td>
</tr>
<tr>
<td>Tempo/Threshold Training</td>
</tr>
<tr>
<td>Interval Training</td>
</tr>
<tr>
<td>Repetition Training (speed)</td>
</tr>
<tr>
<td>Hill Training</td>
</tr>
<tr>
<td>Fartlek Training</td>
</tr>
<tr>
<td>Distance of Weekly Long Run During period</td>
</tr>
<tr>
<td>Average minutes spent cross training per week</td>
</tr>
<tr>
<td>Average minutes spent on flexibility per week</td>
</tr>
<tr>
<td>Strength training</td>
</tr>
<tr>
<td>Speed/form drill and Plyometrics</td>
</tr>
<tr>
<td>Core Training</td>
</tr>
<tr>
<td>Rest -- no running/physical activity (not due to injury)</td>
</tr>
<tr>
<td>Average # of runs per week</td>
</tr>
<tr>
<td>Total Days during period unable to run due to injury</td>
</tr>
<tr>
<td>Total Number of Cross Country Races per Period (NCAA sanctioned only)</td>
</tr>
</tbody>
</table>

A special note needs to be made about the high school PR time variable. In the state of Oregon, high school runners compete in the 1500m and 3000m distances, not the 1600m and 3200m distances as all other states do in track. The few Oregon times that will be received will be converted using the International Association of Athletics Federations (IAAF) scoring tables found at iaaf.org (IAAF, 2008). IAAF is the
international governing body of track & field and cross country and these scoring tables are traditionally used to compare performances between various distances and assign a standard point value (IAAF, 2008). This method will allow for the best conversion, as strictly converting using pace would not take into account the different pace that runners utilize in the slightly different distances.

The use of four training phases was determined in the same fashion. The research done by Kurz et al. (2000) was the main determinant of the four period format. Kurz et al. (2000) utilized a three phase format, but it was determined that the first phase, which was twice as long as the second training phase, inherently had more importance due to its length. It was concluded that it should be cut in half to make the first three periods each two months with the last period, peaking, be just the month of November. Therefore the periods were set as summer, May and June, transition, July and August, competition, September and October and peak, November (see table 9).

| Table 9. Breakdown of periods based on month. |
|-----------------|-----------------|-----------------|-----------------|-----------------|
| Summer          | Transition      | Competition     | Peak            |
| May/June        | July/August    | September/October | November        |

The variables and training periods were put into Microsoft Excel and the online survey software to allow for maximum readability with a page of directions attached (see appendixes B and C). In the directions, many of the variables were defined as to limit confusion because many variables may have multiple meanings. To keep the data consistent between subjects, common definitions were needed. These definitions were taken from research and written so that runners would easily understand them.

Overall, the directions and the survey are very important to obtaining pertinent and consistent data.

**Recruitment of Subjects and Distribution of the Survey**

The subjects in the survey were the finishers of the 2008 NCAA Cross Country Champion 10k race. There were 252 possible participants, based on the number of finishers in the race (NCAA Cross Country Championship Central, 2008). All of the 2008
qualifiers were asked to participate and fill out a completed survey within the set time frame. Assuming a participation rate of 50%, based on previous research (Karp, 2007; Kurz, Berg, Latin, & deGraw, 2000), 126 subjects were expected to return surveys. Unfortunately, the actual return rate was only 16.7% (42 of the possible 252 participants).

The results of the 2008 NCAA Cross Country Championship race were downloaded from the NCAA official website after they were made official (National Collegiate Athletic Association (NCAA) Website, 2008). The race was held on Monday, November 24, 2008 in Terre Haute, Indiana, and official results were posted within 24 hours of completion of the race (appendix A). The finishers were set as the population of this study.

First, a list of schools, coaches, number of runners from that school, and contact information of e-mail address, mailing address, and phone number were formed from the results (appendix J). This was the master list. Coaches’ contact information was found using the internet. The NCAA.org website has a page which directly links to each school’s athletic website (National Collegiate Athletic Association (NCAA) Website, 2008). Coaches’ e-mail address, phone number, and mailing address were accessed and recorded from the individual schools’ website.

During contact, coaches were informed of the study, requested to give his/her runners the online survey information, and informed that all data would be treated with confidentiality. Contact was made several times and in three modes, e-mail, mail, and phone (table 10). Directions, intended to be distributed to the athletes by the coaches, on how to participate in this research were also be included in all e-mails and mailings (see appendix C). A copy of the survey and the directions were also attached to the e-mails and the letter so that the coaches can see the questions for themselves (see appendix D). Finally, during all contact, coaches were assured that all data would be kept confidential and the surveys anonymous. Because individual runner contact information is kept private while coaches’ contact information is publicly posted by the
athletic departments, coaches had to be contacted and asked to distribute the survey information to the athletes.

Table 10. Actual timeline of contact with coaches.

<table>
<thead>
<tr>
<th>Date</th>
<th>Method Contacted</th>
<th>Reason</th>
<th>Appendix</th>
</tr>
</thead>
<tbody>
<tr>
<td>November 24, 2008</td>
<td>NCAA Championship Meet</td>
<td>Official results posted, master coaches' contact information compiled.</td>
<td>K</td>
</tr>
<tr>
<td>November 25, 2008</td>
<td>E-mail</td>
<td>Inform on Online Survey, request to participate and distribute URL.</td>
<td>B</td>
</tr>
<tr>
<td>December 3, 2008</td>
<td>Mail</td>
<td>Letter with set of online survey directions for each runner.</td>
<td>C, D, E</td>
</tr>
<tr>
<td>December 12, 2008</td>
<td>E-mail</td>
<td>Asking of receipt of letter and encouragement to participate.</td>
<td>F</td>
</tr>
<tr>
<td>January 27, 2009</td>
<td>E-mail</td>
<td>Thanking participation and encouraging more if possible.</td>
<td>G</td>
</tr>
<tr>
<td>March 12, 2009</td>
<td>E-mail</td>
<td>Final request to coaches who have not responded.</td>
<td>H</td>
</tr>
<tr>
<td>April 15, 2009</td>
<td>E-mail</td>
<td>Asking coaches if they participated and how to improve survey research.</td>
<td>I</td>
</tr>
</tbody>
</table>

Selecting the 2008 NCAA Cross Country Men’s Championship 10k race finishers set a large population of high level runners. These runners were all between the ages of 18 and 23 and attending college who have to follow strict NCAA guidelines, such as a performance enhancing drug policy, financial assistance, practice regulations, and eligibility rules (National Collegiate Athletic Association (NCAA) Website, 2008). This levels the playing field between runners. Using only performance times from the championship 10k race eliminated all course and weather variables. Every runner was competing against each other at the most important race of the cross country season, where they all wanted to run their fastest time. Finally, having multiple contacts in three formats, e-mail, phone call, and letter, was supposed to allow for a large response rate. Every member of the population had the opportunity to participate, and communication variables were minimized. Based on previous research (Karp, 2007; Kurz, Berg, Latin, & deGraw, 2000) the goal was to have 50% participate or 125 subjects. Unfortunately only 42 surveys, out of 252 finishers (16.7%) were fully completed. Four additional surveys were started but not completed. These four surveys were discarded entirely and not used in final analysis in order to allow for accurate data analysis.
The lack of response must be considered a major limitation to the research and although trends may be determined with the results of the 42 completed surveys, significance to the entire population of NCAA cross country championship runners in 2008 or competitive runners in general may not be taken in these results. One positive result of the response is that the distribution of the returned surveys initially seems to be normally distributed based on place (table 11) and time (figure 1).

Table 11. Distribution of surveys based on place (n = 42)

<table>
<thead>
<tr>
<th>Place</th>
<th>n</th>
</tr>
</thead>
<tbody>
<tr>
<td>Top 50</td>
<td>6</td>
</tr>
<tr>
<td>51-100</td>
<td>8</td>
</tr>
<tr>
<td>101-150</td>
<td>10</td>
</tr>
<tr>
<td>151-200</td>
<td>11</td>
</tr>
<tr>
<td>200-251</td>
<td>7</td>
</tr>
</tbody>
</table>

Figure 1. Distribution of surveys based on 10k finish time with normal curve.

Organization and Analysis of the Data

Once subjects were selected, recruited, and finished filling out the online surveys, the data was organized and evaluated to meet the stated goals. The purpose of
this research was to summarize the training methods of male NCAA Cross Country Championship 10k qualifiers and determine what, if any, relationship the selected anthropometric, running history, and training variables have on performance at the championship 10k race.

Survey information was downloaded into Microsoft Excel, compiled, and analyzed utilizing SPSS Statistics software. Data analysis included descriptive statistics of the survey data. A Pearson product moment correlation analysis was used to determine the strength of relationship between performance at the NCAA Cross Country Championship 10k race and anthropometric variables, previous racing variables, and training variables for each training period and the entire season. All results are presented as mean ± standard deviation, and the statistical significance was set at p < 0.05 for all tests.

Multi-way ANOVA tests were performed to determine if the mean differences between the periods within each variable were significantly different. With each variable, the Levene's test of equality of error variances was performed to test the error variance of the variables. Due to significant (p < 0.05) F-values within many of the variables, the Tamhane post-hoc test was selected because it is a conservative test that does not assume homogeneity of variances.

A stepwise multivariate regression analysis was performed to determine a prediction equation for 10k finish time and further analyze which variables had the most effect on performance. Stepwise multivariate regression analysis was chosen due to the large number of variables collected as it will enter and exclude variables based on their strength. All variables, anthropological, run training, and ancillary training from all four periods and the entire season, were entered into the first model. The second model consisted only of run training variables was created to determine which run variables had the greatest effect on training.
CHAPTER FOUR: RESULTS

The results section will answer each of research questions posed in the introduction section.

Descriptive Data

1. What are the training patterns amongst successful male NCAA cross country runners?

After surveys were collected, descriptive characteristics of the male NCAA Cross Country Championship finishers that completed the survey were calculated. Anthropometric variables and Pearson product moment correlation to 10k finish time are listed in table 12. The minimum and maximum 10k finish times were excluded to keep the anonymity of the subjects intact.

Table 12. Anthropometric variables of NCAA Division 1 cross country championship finishers (n = 42).

<table>
<thead>
<tr>
<th>Variable</th>
<th>Min</th>
<th>Max</th>
<th>Mean</th>
<th>S.D.</th>
<th>r*</th>
</tr>
</thead>
<tbody>
<tr>
<td>10k Finish Time (min)</td>
<td>31.17</td>
<td>30.92</td>
<td>20.79</td>
<td>1.46</td>
<td>0.136</td>
</tr>
<tr>
<td>Age (y)</td>
<td>18.00</td>
<td>23.00</td>
<td>20.79</td>
<td>0.98</td>
<td>0.046</td>
</tr>
<tr>
<td>Academic Year (y)</td>
<td>1.00</td>
<td>4.00</td>
<td>2.83</td>
<td>1.03</td>
<td>0.168</td>
</tr>
<tr>
<td>Height (in)</td>
<td>66.00</td>
<td>75.00</td>
<td>71.14</td>
<td>1.23</td>
<td>-0.046</td>
</tr>
<tr>
<td>Weight (lbs)</td>
<td>120.00</td>
<td>165.00</td>
<td>144.31</td>
<td>3.98</td>
<td>0.102</td>
</tr>
<tr>
<td>Body Mass Index (kg/m²)</td>
<td>16.27</td>
<td>22.89</td>
<td>20.06</td>
<td>1.38</td>
<td>0.152</td>
</tr>
<tr>
<td># years running (y)</td>
<td>3.00</td>
<td>16.00</td>
<td>8.05</td>
<td>3.04</td>
<td>0.186</td>
</tr>
<tr>
<td>Pre-college 1600 meter time (min)</td>
<td>4.00</td>
<td>4.55</td>
<td>4.27</td>
<td>0.12</td>
<td>0.369 **</td>
</tr>
<tr>
<td>Pre-college 3200 meter time (min)</td>
<td>8.59</td>
<td>10.40</td>
<td>9.52</td>
<td>0.35</td>
<td>0.319 **</td>
</tr>
<tr>
<td>Pre-college 1600m plus 3200m times (min)</td>
<td>12.59</td>
<td>14.58</td>
<td>13.53</td>
<td>0.42</td>
<td>0.377 **</td>
</tr>
</tbody>
</table>

*The Pearson product moment correlation to the dependent variable of 10k finish time.
**Correlation is significant at the 0.05 level (2-tailed).

The positive sign on all of the correlations indicates that with an increase in the value, the faster the finish time. A significant (p < 0.05) positive correlation existed with pre-college 1600m and 3200m times, indicating that the faster a respondent ran before college, the faster he ran at the national championships. When the 1600m times and 3200m times were added together to create a new variable, the significant (p < 0.05) correlation rose slightly, indicating that respondents who were successful before college ran faster 10k finish times at the NCAA championship race.
The characteristics for each period of the 2008 cross country season were also gathered (see tables 13, 14, 15, 16). Pearson's product moment correlations were also calculated for the dependent variable of 10k finish time. A positive correlation indicates that higher the value of the variable, the slower the finish time while a negative sign indicates that higher the value, the faster the finish time.

Table 13. Summer period training characteristics of NCAA Division 1 cross country championship finishers (n = 42).

<table>
<thead>
<tr>
<th>Per week</th>
<th>Min</th>
<th>Max</th>
<th>Mean</th>
<th>S.D.</th>
<th>r*</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mileage (miles)</td>
<td>7.0</td>
<td>95.0</td>
<td>56.96</td>
<td>18.90</td>
<td>-0.029</td>
</tr>
<tr>
<td># Runs</td>
<td>4.00</td>
<td>14.00</td>
<td>7.32</td>
<td>2.26</td>
<td>-0.021</td>
</tr>
<tr>
<td>Long Run Distance (miles)</td>
<td>6.00</td>
<td>18.00</td>
<td>12.35</td>
<td>2.79</td>
<td>0.005</td>
</tr>
<tr>
<td># Threshold Training Sessions</td>
<td>0.00</td>
<td>3.00</td>
<td>0.53</td>
<td>0.68</td>
<td>0.086</td>
</tr>
<tr>
<td># Interval Training Sessions</td>
<td>0.00</td>
<td>2.00</td>
<td>0.31</td>
<td>0.59</td>
<td>-0.008</td>
</tr>
<tr>
<td># Repetition Training Sessions</td>
<td>0.00</td>
<td>2.00</td>
<td>0.23</td>
<td>0.47</td>
<td>-0.076</td>
</tr>
<tr>
<td># Fartlek Training Sessions</td>
<td>0.00</td>
<td>1.00</td>
<td>0.24</td>
<td>0.40</td>
<td>0.109</td>
</tr>
<tr>
<td># Hill Training Sessions</td>
<td>0.00</td>
<td>5.00</td>
<td>0.26</td>
<td>0.82</td>
<td>0.247</td>
</tr>
<tr>
<td># Races</td>
<td>0.00</td>
<td>2.00</td>
<td>0.07</td>
<td>0.34</td>
<td>-0.096</td>
</tr>
<tr>
<td>Cross Training Sessions</td>
<td>0.00</td>
<td>7.00</td>
<td>0.64</td>
<td>1.22</td>
<td>0.067</td>
</tr>
<tr>
<td>Strength Training Sessions</td>
<td>0.00</td>
<td>6.00</td>
<td>1.12</td>
<td>1.40</td>
<td>-0.055</td>
</tr>
<tr>
<td>Form/Drill Sessions</td>
<td>0.00</td>
<td>3.00</td>
<td>0.50</td>
<td>0.80</td>
<td>0.014</td>
</tr>
<tr>
<td>Core Strength Sessions</td>
<td>0.00</td>
<td>7.00</td>
<td>1.70</td>
<td>2.26</td>
<td>0.259</td>
</tr>
<tr>
<td>Flexibility Training (min/week)</td>
<td>0.00</td>
<td>400.00</td>
<td>53.79</td>
<td>71.86</td>
<td>0.272</td>
</tr>
<tr>
<td>Days of rest, no running</td>
<td>0.00</td>
<td>7.00</td>
<td>1.09</td>
<td>1.45</td>
<td>-0.039</td>
</tr>
<tr>
<td>Days Missed per Period due to Injury</td>
<td>0.00</td>
<td>30.00</td>
<td>2.48</td>
<td>7.15</td>
<td>0.026</td>
</tr>
</tbody>
</table>

*The Pearson product moment correlation to the dependent variable of 10k finish time.

Some of the numbers for the summer period may be skewed as three of the respondents indicated that they missed 25 to 30 days of running due to injury during the months of May and June. In the comments section, one runner stated that he cross trained daily for most of May and started running full time towards the end of May. There were no significant correlations at the 0.05 level.
Table 14. Transition period training characteristics of NCAA Division 1 cross country championship participants (n = 42).

<table>
<thead>
<tr>
<th>Per week</th>
<th>Min</th>
<th>Max</th>
<th>Mean</th>
<th>S.D.</th>
<th>r*</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mileage (miles)</td>
<td>43.00</td>
<td>110.00</td>
<td>75.26</td>
<td>15.41</td>
<td>-0.025</td>
</tr>
<tr>
<td># Runs</td>
<td>5.00</td>
<td>14.00</td>
<td>8.43</td>
<td>2.24</td>
<td>-0.144</td>
</tr>
<tr>
<td>Long Run Distance (miles)</td>
<td>10.00</td>
<td>21.00</td>
<td>15.29</td>
<td>2.70</td>
<td>-0.108</td>
</tr>
<tr>
<td># Threshold Training Sessions</td>
<td>0.00</td>
<td>4.00</td>
<td>1.13</td>
<td>0.80</td>
<td>-0.048</td>
</tr>
<tr>
<td># Interval Training Sessions</td>
<td>0.00</td>
<td>2.00</td>
<td>0.56</td>
<td>0.66</td>
<td>0.032</td>
</tr>
<tr>
<td># Repetition Training Sessions</td>
<td>0.00</td>
<td>2.00</td>
<td>0.40</td>
<td>0.57</td>
<td>-0.032</td>
</tr>
<tr>
<td># Fartlek Training Sessions</td>
<td>0.00</td>
<td>2.00</td>
<td>0.53</td>
<td>0.50</td>
<td>0.112</td>
</tr>
<tr>
<td># Hill Training Sessions</td>
<td>0.00</td>
<td>2.00</td>
<td>0.43</td>
<td>0.55</td>
<td>0.109</td>
</tr>
<tr>
<td># Races</td>
<td>0.00</td>
<td>2.00</td>
<td>0.19</td>
<td>0.45</td>
<td>-0.185</td>
</tr>
<tr>
<td>Cross Training Sessions</td>
<td>0.00</td>
<td>12.00</td>
<td>0.80</td>
<td>1.96</td>
<td>-0.072</td>
</tr>
<tr>
<td>Strength Training Sessions</td>
<td>0.00</td>
<td>6.00</td>
<td>1.55</td>
<td>1.43</td>
<td>-0.039</td>
</tr>
<tr>
<td>Form/Drill Sessions</td>
<td>0.00</td>
<td>5.00</td>
<td>1.03</td>
<td>1.17</td>
<td>0.340  **</td>
</tr>
<tr>
<td>Core Strength Sessions</td>
<td>0.00</td>
<td>8.00</td>
<td>2.65</td>
<td>2.31</td>
<td>0.237</td>
</tr>
<tr>
<td>Flexibility Training (min/week)</td>
<td>0.00</td>
<td>400.00</td>
<td>54.76</td>
<td>72.85</td>
<td>0.301</td>
</tr>
<tr>
<td>Days of rest, no running</td>
<td>0.00</td>
<td>2.00</td>
<td>0.39</td>
<td>0.54</td>
<td>-0.004</td>
</tr>
<tr>
<td>Days Missed per Period due to Injury</td>
<td>0.00</td>
<td>30.00</td>
<td>1.29</td>
<td>4.84</td>
<td>-0.097</td>
</tr>
</tbody>
</table>

*The Pearson product moment correlation to the dependent variable of 10k finish time.

**Correlation is significant at the 0.05 level (2-tailed).

The only significant (p < 0.05) findings in the transition period is the positive correlation to 10k finish time of form/drill sessions. Respondents who did more form/drill training sessions per week ran slower at the championship race. All other correlations were very weak and statistically not significant. An interesting note is that the runner who missed 30 days of running in the transition period due to injury during the 2 month period was also the runner that reported cross training 12 times per week. Most likely he was cross training to make up for lost running time.
Table 15. Competition period training characteristics of NCAA Division 1 cross country championship finishers (n = 42).

<table>
<thead>
<tr>
<th>Per week</th>
<th>Min</th>
<th>Max</th>
<th>Mean</th>
<th>S.D.</th>
<th>r*</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mileage (miles)</td>
<td>45.00</td>
<td>112.00</td>
<td>80.22</td>
<td>13.88</td>
<td>0.016</td>
</tr>
<tr>
<td># Runs</td>
<td>5.00</td>
<td>14.00</td>
<td>8.99</td>
<td>1.81</td>
<td>0.014</td>
</tr>
<tr>
<td>Long Run Distance (miles)</td>
<td>10.00</td>
<td>22.50</td>
<td>15.99</td>
<td>2.60</td>
<td>0.013</td>
</tr>
<tr>
<td># Threshold Training Sessions</td>
<td>0.00</td>
<td>4.00</td>
<td>1.23</td>
<td>0.72</td>
<td>0.229</td>
</tr>
<tr>
<td># Interval Training Sessions</td>
<td>0.50</td>
<td>3.00</td>
<td>1.30</td>
<td>0.56</td>
<td>-0.050</td>
</tr>
<tr>
<td># Repetition Training Sessions</td>
<td>0.00</td>
<td>3.00</td>
<td>0.72</td>
<td>0.68</td>
<td>0.059</td>
</tr>
<tr>
<td># Fartlek Training Sessions</td>
<td>0.00</td>
<td>2.00</td>
<td>0.74</td>
<td>0.54</td>
<td>0.264</td>
</tr>
<tr>
<td># Hill Training Sessions</td>
<td>0.00</td>
<td>2.00</td>
<td>0.56</td>
<td>0.49</td>
<td>0.127</td>
</tr>
<tr>
<td># Races</td>
<td>1.00</td>
<td>4.00</td>
<td>3.14</td>
<td>0.81</td>
<td>0.225</td>
</tr>
<tr>
<td>Cross Training Sessions</td>
<td>0.00</td>
<td>2.00</td>
<td>0.24</td>
<td>0.53</td>
<td>0.185</td>
</tr>
<tr>
<td>Strength Training Sessions</td>
<td>0.00</td>
<td>6.00</td>
<td>2.14</td>
<td>1.46</td>
<td>-0.244</td>
</tr>
<tr>
<td>Form/Drill Sessions</td>
<td>0.00</td>
<td>5.00</td>
<td>1.52</td>
<td>1.19</td>
<td>0.036</td>
</tr>
<tr>
<td>Core Strength Sessions</td>
<td>0.00</td>
<td>7.00</td>
<td>3.21</td>
<td>1.76</td>
<td>0.191</td>
</tr>
<tr>
<td>Flexibility Training (min/week)</td>
<td>0.00</td>
<td>400.00</td>
<td>68.07</td>
<td>78.89</td>
<td>0.255</td>
</tr>
<tr>
<td>Days of rest, no running</td>
<td>0.00</td>
<td>2.00</td>
<td>0.28</td>
<td>0.44</td>
<td>0.035</td>
</tr>
<tr>
<td>Days Missed per Period due to Injury</td>
<td>0.00</td>
<td>7.00</td>
<td>1.40</td>
<td>2.06</td>
<td>-0.025</td>
</tr>
</tbody>
</table>

*The Pearson product moment correlation to the dependent variable of 10k finish time.

There were no significant correlations between the independent variables and the dependent variable of 10k finish time during the competition period. It is interesting to note that the average runner in the sample ran 80 miles per week, the most of any of the four periods, despite racing an average of three times in the two months, or almost every other week.
Table 16. Peaking period training characteristics of NCAA Division 1 cross country championship finishers (n = 42).

<table>
<thead>
<tr>
<th>Per week</th>
<th>Min</th>
<th>Max</th>
<th>Mean</th>
<th>S.D.</th>
<th>$r^*$</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mileage (miles)</td>
<td>45.00</td>
<td>90.00</td>
<td>68.34</td>
<td>11.92</td>
<td>0.137</td>
</tr>
<tr>
<td># Runs</td>
<td>5.00</td>
<td>16.00</td>
<td>8.12</td>
<td>2.05</td>
<td>0.029</td>
</tr>
<tr>
<td>Long Run Distance (miles)</td>
<td>8.00</td>
<td>17.00</td>
<td>13.11</td>
<td>2.09</td>
<td>-0.068</td>
</tr>
<tr>
<td># Threshold Training Sessions</td>
<td>0.00</td>
<td>3.00</td>
<td>0.93</td>
<td>0.61</td>
<td>0.309  **</td>
</tr>
<tr>
<td># Interval Training Sessions</td>
<td>0.50</td>
<td>2.00</td>
<td>1.15</td>
<td>0.39</td>
<td>-0.003</td>
</tr>
<tr>
<td># Repetition Training Sessions</td>
<td>0.00</td>
<td>3.00</td>
<td>0.86</td>
<td>0.61</td>
<td>0.069</td>
</tr>
<tr>
<td># Fartlek Training Sessions</td>
<td>0.00</td>
<td>2.00</td>
<td>0.51</td>
<td>0.60</td>
<td>0.241</td>
</tr>
<tr>
<td># Hill Training Sessions</td>
<td>0.00</td>
<td>1.00</td>
<td>0.15</td>
<td>0.34</td>
<td>0.058</td>
</tr>
<tr>
<td>Cross Training Sessions</td>
<td>1.00</td>
<td>3.00</td>
<td>2.33</td>
<td>0.65</td>
<td>-0.219</td>
</tr>
<tr>
<td>Strength Training Sessions</td>
<td>0.00</td>
<td>6.00</td>
<td>1.42</td>
<td>1.43</td>
<td>-0.147</td>
</tr>
<tr>
<td>Form/Drill Sessions</td>
<td>0.00</td>
<td>5.00</td>
<td>0.99</td>
<td>1.08</td>
<td>0.174</td>
</tr>
<tr>
<td>Core Strength Sessions</td>
<td>0.00</td>
<td>7.00</td>
<td>2.57</td>
<td>1.88</td>
<td>0.265</td>
</tr>
<tr>
<td>Flexibility Training (min/week)</td>
<td>0.00</td>
<td>400.00</td>
<td>66.12</td>
<td>78.18</td>
<td>0.272</td>
</tr>
<tr>
<td>Days of rest, no running</td>
<td>0.00</td>
<td>2.00</td>
<td>0.24</td>
<td>0.45</td>
<td>-0.084</td>
</tr>
<tr>
<td>Days Missed per Period due to Injury</td>
<td>0.00</td>
<td>10.00</td>
<td>0.90</td>
<td>2.16</td>
<td>-0.066</td>
</tr>
</tbody>
</table>

*The Pearson product moment correlation to the dependent variable of 10k finish time.
**Correlation is significant at the 0.05 level (2-tailed).

Peaking period training characteristics are shown in table 17. The only significant (p < 0.05) correlation to 10k finish time was the number of threshold/tempo run sessions performed. Respondents who performed more sessions of threshold/tempo run training ran slower at the NCAA championships. All other correlations to finish time were not significant at the 0.05 level.

Variables were calculated using the four periods of the season to create an average week for the entire season (table 17). All variables were averaged from the four periods except for long run, races, and days missed due to injury. The long run variable was created by determining the longest run for each runner during the entire season. The respondents’ longest run of the season averaged 16.4±2.63 miles. Number of races and days missed due to injury variables were created by total the value for the entire season. Respondents averaged 5.82±1.21 races and 6.44±9.0 days missed for the
entire season. There were no significant (p < 0.05) correlations to 10k finish time at the NCAA championships for any of the composite training variables.

Table 17. Composite training characteristics of NCAA Division 1 cross country championship finishers (n = 42).

<table>
<thead>
<tr>
<th>Per week+</th>
<th>Min</th>
<th>Max</th>
<th>Mean</th>
<th>S.D.</th>
<th>r*</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mileage (miles)</td>
<td>40.75</td>
<td>96.75</td>
<td>70.19</td>
<td>12.32</td>
<td>0.019</td>
</tr>
<tr>
<td># Runs</td>
<td>5.00</td>
<td>12.50</td>
<td>8.21</td>
<td>1.67</td>
<td>-0.043</td>
</tr>
<tr>
<td>Longest Long-Run Distance (miles)+</td>
<td>12.00</td>
<td>22.50</td>
<td>16.44</td>
<td>2.55</td>
<td>-0.165</td>
</tr>
<tr>
<td># Threshold Training Sessions</td>
<td>0.25</td>
<td>2.75</td>
<td>0.95</td>
<td>0.51</td>
<td>0.183</td>
</tr>
<tr>
<td># Interval Training Sessions</td>
<td>0.38</td>
<td>1.75</td>
<td>0.83</td>
<td>0.36</td>
<td>-0.010</td>
</tr>
<tr>
<td># Repetition Training Sessions</td>
<td>0.00</td>
<td>1.75</td>
<td>0.55</td>
<td>0.43</td>
<td>0.016</td>
</tr>
<tr>
<td># Fartlek Training Sessions</td>
<td>0.00</td>
<td>1.50</td>
<td>0.50</td>
<td>0.33</td>
<td>0.292</td>
</tr>
<tr>
<td># Hill Training Sessions</td>
<td>0.00</td>
<td>2.00</td>
<td>0.35</td>
<td>0.35</td>
<td>0.245</td>
</tr>
<tr>
<td>Total # Races+</td>
<td>3.00</td>
<td>8.00</td>
<td>5.74</td>
<td>1.21</td>
<td>-0.063</td>
</tr>
<tr>
<td>Cross Training Sessions</td>
<td>0.00</td>
<td>3.00</td>
<td>0.45</td>
<td>0.67</td>
<td>0.020</td>
</tr>
<tr>
<td>Strength Training Sessions</td>
<td>0.00</td>
<td>6.00</td>
<td>1.56</td>
<td>1.26</td>
<td>-0.138</td>
</tr>
<tr>
<td>Form/Drill Sessions</td>
<td>0.00</td>
<td>3.75</td>
<td>1.01</td>
<td>0.82</td>
<td>0.195</td>
</tr>
<tr>
<td>Core Strength Sessions</td>
<td>0.25</td>
<td>7.00</td>
<td>2.53</td>
<td>1.73</td>
<td>0.284</td>
</tr>
<tr>
<td>Flexibility Training (min/week)</td>
<td>0.00</td>
<td>400.00</td>
<td>60.68</td>
<td>73.52</td>
<td>0.282</td>
</tr>
<tr>
<td>Days of rest, no running</td>
<td>0.00</td>
<td>2.00</td>
<td>0.50</td>
<td>0.54</td>
<td>-0.038</td>
</tr>
<tr>
<td>Days Missed Entire Season Due to Injury+</td>
<td>0.00</td>
<td>36.00</td>
<td>6.07</td>
<td>8.86</td>
<td>-0.054</td>
</tr>
</tbody>
</table>

+Variable not averaged.

Two variables, days missed due to injury and flexibility training, had a disproportionately large standard deviation and were further analyzed. Figures 2 and 3 show the reported frequency of each variable. The majority of respondents reported that they trained for flexibility less than 100 minutes per week (n = 36, 86%) while only a few reported more than 100 minutes per week (n = 6, 14%) for the entire season. Nine of the respondents (21%) reported 10 minutes or less of flexibility training per week during the season. This shows that most runners do not spend much time while a few spend a lot of time on flexibility training.

Responses to days missed from running due to injury were similar to flexibility training responses. A large majority of the runners were healthy throughout the entire season, missing seven days or less (n = 33, 79%) while a few missed a moderate amount
of days, between eight and 12 inclusive (n = 5, 12%), and four missed 25 to 36 days inclusive (10%). This indicates that most runners who qualified for the NCAA championship cross country meet were mostly healthy and able to run the set workout for most of the season.

**Stepwise Regression Analysis**

Stepwise regression analysis was performed utilizing all anthropometric variables and training variables from each period plus the season composite variables. Stepwise multiple regression analysis was chosen due to its use in previous research (Kurz, Berg, Latin, & deGraw, 2000; Karp, 2007) and the large number of predictor variables. The analysis systematically selects significant predictors while excluding variables that are not significant and concludes with the most efficient model to predict 10k finish time. All variables were standardized before the stepwise regression analysis and two models were created, one with the original variables and one with the standardized variables. This was done to assure that the unequal measurement of the variables did not affect the outcome while still generating a prediction equation of 10k finish time. The stepwise multiple regression equation is presented in table 18.

**Table 18. Stepwise multiple regression analysis to predict 10k finish time based on all anthropometric and training variables collected.**

<table>
<thead>
<tr>
<th>Equation*</th>
<th>R</th>
<th>Adjusted R²</th>
<th>Significance</th>
</tr>
</thead>
<tbody>
<tr>
<td>10k time = 22.26 + 0.38 (PCT)</td>
<td>0.377</td>
<td>0.121</td>
<td>0.14</td>
</tr>
<tr>
<td>10k time = 19.90 + 0.46 (PCT) + 0.37 (CP)</td>
<td>0.521</td>
<td>0.234</td>
<td>0.002</td>
</tr>
<tr>
<td>10k time = 20.27 + 0.44 (PCT) + 0.36 (CP) + 0.30 (DT)</td>
<td>0.602</td>
<td>0.312</td>
<td>0.001</td>
</tr>
</tbody>
</table>

* PCT = pre-college one mile plus two mile time; CP = number of core sessions during the peak period; DT = number of form/drill sessions during the transition period

In both the original and standardized variable models, the coefficients and significance values were the same, only the intercept value was changed. The results show that pre-college mile plus two mile time (PCT) explains 12.1% of the variance for respondents finish time, which was the best predictor amongst all of the variables. Further performing the stepwise regression analysis model, the number of core sessions
during the peak period and form/drift sessions during the transition period also show significant \((p < 0.01)\) contribution. The positive sign of each variable indicates that the more each variable is performed, the slower the finish time of the respondents. All other variables were excluded from the equation due to a lack of significance \((p < 0.05)\). The multiple regression analysis shows that these three variables, especially HST, are the most important when trying to predict 10k finish time amongst the respondents.

An additional stepwise regression model was created with run training variables only from each period and the season composite variables (mileage, number of runs per week, long run, threshold training, interval training, repetition training, hill training, and number of races) (table 19). This was performed to determine if any of the run training variables had significance. The only variable that was included in the stepwise regression model was the number of threshold training sessions during the peak period and although significant \((p = 0.046)\), it only explains 7.3\% of the variance of 10k finish time.

<table>
<thead>
<tr>
<th>Table 19. Stepwise multiple regression analysis to predict 10k finish time based on run-training variables only.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Equation*</td>
</tr>
<tr>
<td>10k time = 30.82 + 0.31 (TP)</td>
</tr>
<tr>
<td>*TP = Number of threshold training sessions during the peak period.</td>
</tr>
</tbody>
</table>

Training Progression throughout the Season

The inter-season training patterns were also examined. Comparing the four periods of the season, volume, training intensity, and ancillary training increases from the summer period to the competition period and then decrease from the competition period to the peak period. This is evident in most variables describing volume of training (mileage, runs per week, long run distance, and days of rest), intensity of training (number of threshold, interval, repetition, fartlek, and hill sessions per week
along with the number of races per period), and ancillary training (number of strength, form/drills, and core sessions per week).

Multi-way ANOVA tests were performed to determine if the mean differences between the periods within each variable were significantly \( p < 0.05 \) different. There were differences in the means between the periods in each variable except for days missed during each period due to injury, average sessions per week of cross training, and minutes spent on flexibility training per week. With each variable, the Levene’s test of equality of error variances (table 20) was performed to test the error variance of the variables. Due to significant \( p < 0.05 \) F-values within many of the variables, the Tamhane post-hoc test was selected because it a conservative test that does not assume homogeneity of variances (figures 2 thru 9).

<table>
<thead>
<tr>
<th>Training Variable</th>
<th>F</th>
<th>( p^* )</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mileage (miles)</td>
<td>3.666</td>
<td>0.014(^*)</td>
</tr>
<tr>
<td># Runs</td>
<td>0.778</td>
<td>0.508</td>
</tr>
<tr>
<td>Long Run Distance (miles)</td>
<td>0.853</td>
<td>0.467</td>
</tr>
<tr>
<td># Threshold Training Sessions</td>
<td>0.935</td>
<td>0.425</td>
</tr>
<tr>
<td># Interval Training Sessions</td>
<td>6.131</td>
<td>0.001(^*)</td>
</tr>
<tr>
<td># Repetition Training Sessions</td>
<td>1.777</td>
<td>0.154</td>
</tr>
<tr>
<td># Fartlek Training Sessions</td>
<td>2.234</td>
<td>0.086</td>
</tr>
<tr>
<td># Hill Training Sessions</td>
<td>2.257</td>
<td>0.084</td>
</tr>
<tr>
<td># Races</td>
<td>18.322</td>
<td>0.000(^*)</td>
</tr>
<tr>
<td>Cross Training Sessions</td>
<td>4.873</td>
<td>0.003(^*)</td>
</tr>
<tr>
<td>Strength Training Sessions</td>
<td>0.625</td>
<td>0.600</td>
</tr>
<tr>
<td>Form/Drill Sessions</td>
<td>1.682</td>
<td>0.173</td>
</tr>
<tr>
<td>Core Strength Sessions</td>
<td>1.421</td>
<td>0.239</td>
</tr>
<tr>
<td>Flexibility Training (min/week)</td>
<td>0.381</td>
<td>0.767</td>
</tr>
<tr>
<td>Days of rest, no running</td>
<td>15.565</td>
<td>0.000(^*)</td>
</tr>
<tr>
<td>Days Missed per Period due to Injury</td>
<td>5.791</td>
<td>0.001(^*)</td>
</tr>
</tbody>
</table>

\( ^* \) Tests the null hypothesis that the error variance of the dependent variable is equal across groups.

\( ^\d \) Design: Intercept + Period.

\( ^\# \) Significant to the 0.05 level.
Figure 2. Progression of weekly mileage throughout the entire season. S = Significantly (p < 0.05) different from the summer period. C = Significantly (p < 0.05) different than the competition period.

Figure 3. Progression of number of weekly runs throughout the entire season. S = Significantly (p < 0.05) different from the summer period.
**Figure 4.** Progression of the long run throughout the entire season.  S = Significantly (p < 0.05) different from the summer period.  T = Significantly (p < 0.05) different from the transition period.  C = Significantly (p < 0.05) different than the competition period.

**Figure 5.** Progression of days missed due to rest and injury throughout the entire season.  S = Significantly (p < 0.05) different from the summer period.  No significant (p < 0.05) differences exist between periods for the days missed due to injury variable.
Figure 6. Progression of selected high intensity training variables throughout the entire season. S = Significantly (p < 0.05) different from the summer period. T = Significantly (p < 0.05) different from the transition period. C = Significantly (p < 0.05) different than the competition period.

Figure 7. Progression of the number of races throughout the entire season. S = Significantly (p < 0.05) different from the summer period. T = Significantly (p < 0.05) different from the transition period.
Figure 8. Progression of selected ancillary training variables throughout the entire season. S = Significantly (p < 0.05) different from the summer period. No significant (p < 0.05) differences exist between periods for the average days per week of cross training variable.

Figure 9. Progression of weekly mileage throughout the entire season. No significant (p < 0.05) differences exist between periods for the minutes spent per week on flexibility training variable.
Relationships to Performance amongst Variables

2. What is the relationship between age and performance at the 2008 NCAA Championship meet amongst male 10k finishers?

The Pearson product moment correlation between age and 10k finish time was 0.136 which was not significant (p = 0.390).

3. What is the relationship between academic year and performance at the 2008 NCAA Championship meet amongst male 10k finishers?

The Pearson product moment correlation between academic year and 10k finish time was 0.168 which was not significant (p = 0.286).

4. What is the relationship between height and performance at the 2008 NCAA Championship meet amongst male 10k finishers?

The Pearson product moment correlation between height and 10k finish time was -0.047 which was not significant (p = 0.770).

5. What is the relationship between weight and performance at the 2008 NCAA Championship meet amongst male 10k finishers?

The Pearson product moment correlation between weight and 10k finish time was 0.102 which was not significant (p = 0.519).

6. What is the relationship between body mass index and performance at the 2008 NCAA Championship meet amongst male 10k finishers?

The Pearson product moment correlation between body mass index and 10k finish time was 0.151 which was not significant (p = 0.337).

7. What is the relationship between number of years running and performance at the 2008 NCAA Championship meet amongst male 10k finishers?
The Pearson product moment correlation between height and 10k finish time was 0.186 which was not significant (p = 0.238).

8. What is the relationship between pre-college 1500/1600 meter personal best times and performance at the 2008 NCAA Championship meet amongst male 10k finishers?

The Pearson product moment correlation between pre-college 1500/1600 meter personal best times was 0.369 which was significant (p = 0.016) and indicates that faster high school 1500/1600 meter personal best times lead to faster NCAA championship 10k finish times amongst the respondents.

9. What is the relationship between pre-college 3000/3200 meter personal best times and performance at the 2008 NCAA Championship meet amongst male 10k finishers?

The Pearson product moment correlation between pre-college 3000/3200 meter personal best times was 0.319 which was significant (p = 0.039) and indicates that faster high school 3000/3200 meter personal best times lead to faster NCAA championship 10k finish times amongst the respondents.

10. What is the relationship between the addition of pre-college 1500/1600 meter and 3000/3200 meter personal best times and performance at the 2008 NCAA Championship meet amongst male 10k finishers?

The Pearson product moment correlation between the addition of pre-college 1500/1600 meter and 3000/3200 meter personal best times was 0.378 which was significant (p = 0.014) and indicates that faster pre-college 1500/1600 meter and 3000/3200 personal best times lead to faster NCAA championship 10k finish times amongst the respondents.
11. What is the relationship between weekly mileage and performance at the 2008 NCAA Championship meet amongst male 10k finishers:
   a. During the summer period.
   The Pearson product moment correlation between average weekly mileage during the summer period and 10k finish time was -0.029 which was not significant (p = 0.858).
   b. During the transition period.
   The Pearson product moment correlation between average weekly mileage during the transition period and 10k finish time was calculated to be -0.025 which was not significant (p = 0.875).
   c. During the competition period.
   the Pearson product moment correlation between average weekly mileage during the competition period and 10k finish time was 0.016 which was not significant (p = 0.921).
   d. During the peak period.
   The Pearson product moment correlation between average weekly mileage during the peak period and 10k finish time was 0.137 which was not significant (p = 0.387).
   e. During the entire season.
   The Pearson product moment correlation between average weekly mileage during the entire season and 10k finish time was 0.019 which was not significant (p = 0.906).

12. What is the relationship between average number of runs per week and performance at the 2008 NCAA Championship meet amongst male 10k finishers:
   a. During the summer period.
   The Pearson product moment correlation between the average number of runs per week during the summer period and 10k finish time was -0.021 which was not significant (p = 0.895).
   b. During the transition period.
   The Pearson product moment correlation between the average number of runs per week during the transition period and 10k finish time was -0.144 which was not significant (p = 0.362).
c. *During the competition period.*

The Pearson product moment correlation between the average number of runs per week during the competition period and 10k finish time was 0.014 which was not significant \( (p = 0.931) \).

d. *During the peak period.*

The Pearson product moment correlation between the average number of runs per week during the peak period and 10k finish time was 0.029 which was not significant \( (p = 0.854) \).

e. *During the entire season.*

The Pearson product moment correlation between the average number of runs per week during the entire season and 10k finish time was -0.043 which was not significant \( (p = 0.787) \).

13. **What is the relationship between distance of the longest run and performance at the 2008 NCAA Championship meet amongst male 10k finishers:**

   a. *During the summer period.*

   The Pearson product moment correlation between the distance of the longest run during the summer period and 10k finish time was 0.005 which was not significant \( (p = 0.974) \).

   b. *During the transition period.*

   The Pearson product moment correlation between the distance of the longest run during the transition period and 10k finish time was -0.108 which was not significant \( (p = 0.497) \).

   c. *During the competition period.*

   The Pearson product moment correlation between the distance of the longest run during the competition period and 10k finish time was 0.013 which was not significant \( (p = 0.937) \).

   d. *During the peak period.*
The Pearson product moment correlation between the distance of the longest run during the peak period and 10k finish time was -0.068 which was not significant (p = 0.671).

e. During the entire season.
The Pearson product moment correlation between the distance of the longest run during the entire season and 10k finish time was -0.165 which was not significant (p = 0.296).

14. What is the relationship between average weekly sessions of threshold training and performance at the 2008 NCAA Championship meet amongst male 10k finishers:

a. During the summer period.
The Pearson product moment correlation between the number of weekly threshold training sessions during the summer period and 10k finish time was 0.086 which was not significant (p = 0.587).

b. During the transition period.
The Pearson product moment correlation between the number of weekly threshold training sessions during the transition period and 10k finish time was -0.048 which was not significant (p = 0.764).

c. During the competition period.
The Pearson product moment correlation between the number of weekly threshold training sessions during the competition period and 10k finish time was 0.229 which was not significant (p = 0.145).

d. During the peak period.
The Pearson product moment correlation between the number of weekly threshold training sessions during the peak period and 10k finish time was 0.309 which was significant (p = 0.046). This indicates that more threshold training sessions during the peak period correlates to slower a 10k finish time at the NCAA championships amongst the respondents.

e. During the entire season.
The Pearson product moment correlation between the number of weekly threshold training sessions during the entire season and 10k finish time was 0.183 which was **not significant** \( p = 0.246 \).

**15. What is the relationship between average weekly sessions of interval training and performance at the 2008 NCAA Championship meet amongst male 10k finishers:**

- **a. During the summer period.**

  The Pearson product moment correlation between the number of weekly interval training sessions during the summer period and 10k finish time was -0.008 which was **not significant** \( p = 0.958 \).

- **b. During the transition period.**

  The Pearson product moment correlation between the number of weekly interval training sessions during the transition period and 10k finish time was 0.032 which was **not significant** \( p = 0.842 \).

- **c. During the competition period.**

  The Pearson product moment correlation between the number of weekly interval training sessions during the competition period and 10k finish time was -0.050 which was **not significant** \( p = 0.752 \).

- **d. During the peak period.**

  The Pearson product moment correlation between the number of weekly interval training sessions during the peak period and 10k finish time was -0.003 which was **not significant** \( p = 0.983 \).

- **e. During the entire season.**

  The Pearson product moment correlation between the number of weekly interval training sessions during the entire season and 10k finish time was -0.010 which was **not significant** \( p = 0.951 \).

**16. What is the relationship between average weekly sessions of repetition training and performance at the 2008 NCAA Championship meet amongst male 10k finishers:**
a. *During the summer period.*
The Pearson product moment correlation between the number of weekly repetition training sessions during the summer period and 10k finish time was -0.076 which was **not significant** (p = 0.630).

b. *During the transition period.*
The Pearson product moment correlation between the number of weekly repetition training sessions and 10k finish time during the transition period was -0.032 which was **not significant** (p = 0.839).

c. *During the competition period.*
The Pearson product moment correlation between the number of weekly repetition training sessions during the competition period and 10k finish time was 0.059 which was **not significant** (p = 0.710).

d. *During the peak period.*
The Pearson product moment correlation between the number of weekly repetition training sessions during the peak period and 10k finish time was 0.069 which was **not significant** (p = 0.666).

e. *During the entire season.*
The Pearson product moment correlation between the number of weekly repetition training sessions during the entire season and 10k finish time was 0.016 which was **not significant** (p = 0.919).

17. *What is the relationship between average weekly sessions of fartlek training and performance at the 2008 NCAA Championship meet amongst male 10k finishers:*  
a. *During the summer period.*
The Pearson product moment correlation between the number of weekly fartlek training sessions during the summer period and 10k finish time was 0.109 which was **not significant** (p = 0.490).

b. *During the transition period.*
The Pearson product moment correlation between the number of weekly fartlek training sessions during the transition period and 10k finish time was 0.112 which was **not significant** (p = 0.479).

c. **During the competition period.**
The Pearson product moment correlation between the number of weekly fartlek training sessions during the competition period and 10k finish time was 0.264 which was **not significant** (p = 0.091).

d. **During the peak period.**
The Pearson product moment correlation between the number of weekly fartlek training sessions during the peak period and 10k finish time was 0.241 which was **not significant** (p = 0.124).

e. **During the entire season.**
The Pearson product moment correlation between the number of weekly fartlek training sessions during the entire season and 10k finish time was 0.292 which was **not significant** (p = 0.061).

18. What is the relationship between **average weekly sessions of hill training** and **performance at the 2008 NCAA Championship meet amongst male 10k finishers:**

   a. **During the summer period.**
The Pearson product moment correlation between the number of weekly hill training sessions during the summer period and 10k finish time was 0.247 which was **not significant** (p = 0.114).

   b. **During the transition period.**
The Pearson product moment correlation between the number of weekly hill training sessions during the transition period and 10k finish time was 0.109 which was **not significant** (p = 0.493).

   c. **During the competition period.**
The Pearson product moment correlation between the number of weekly hill training sessions during the competition period and 10k finish time was 0.127 which was not significant (p = 0.422).

d. *During the peak period.*
The Pearson product moment correlation between the number of weekly hill training sessions during the peak period and 10k finish time was 0.058 which was not significant (p = 0.716).

e. *During the entire season.*
The Pearson product moment correlation between the number of weekly hill training sessions during the entire season and 10k finish time was 0.245 which was not significant (p = 0.117).

19. *What is the relationship between number of NCAA sanctioned races and performance at the 2008 NCAA Championship meet amongst male 10k finishers:*  
   a. *During the summer period.*
The Pearson product moment correlation between the number of NCAA races during the summer period and 10k finish time was -0.096 which was not significant (p = 0.545).

   b. *During the transition period.*
The Pearson product moment correlation between the number of NCAA races during the transition period and 10k finish time was -0.185 which was not significant (p = 0.241).

   c. *During the competition period.*
The Pearson product moment correlation between the number of NCAA races during the competition period and 10k finish time was 0.244 which was not significant (p = 0.153).

   d. *During the peak period.*
The Pearson product moment correlation between the number of NCAA races during the peak period and 10k finish time was -0.219 which was not significant (p = 0.164).

   e. *During the entire season.*
The Pearson product moment correlation between the number of NCAA races during the entire season and 10k finish time was -0.063 which was **not significant** (p = 0.692).

20. **What is the relationship between average weekly sessions of cross training and performance at the 2008 NCAA Championship meet amongst male 10k finishers:**
   
a. **During the summer period.**
The Pearson product moment correlation between the average number of weekly cross training sessions during the summer period and 10k finish time was 0.067 which was **not significant** (p = 0.672).

   b. **During the transition period.**
The Pearson product moment correlation between the average number of weekly cross training sessions during the transition period and 10k finish time was -0.072 which was **not significant** (p = 0.650).

   c. **During the competition period.**
The Pearson product moment correlation between the average number of weekly cross training sessions during the competition period and 10k finish time was 0.185 which was **not significant** (p = 0.240).

   d. **During the peak period.**
The Pearson product moment correlation between the average number of weekly cross training sessions during the peak period and 10k finish time was 0.047 which was **not significant** (p = 0.765).

   e. **During the entire season.**
The Pearson product moment correlation between the average number of weekly cross training sessions during the entire season and 10k finish time was 0.020 which was **not significant** (p = 0.898).

21. **What is the relationship between average weekly sessions of strength training and performance at the 2008 NCAA Championship meet amongst male 10k finishers:**
   
a. **During the summer period.**
The Pearson product moment correlation between the average number of weekly strength training sessions per week during the summer period and 10k finish time was -0.055 which was not significant \( (p = 0.732) \).

\[ b. \quad \text{During the transition period.} \]

The Pearson product moment correlation between the average number of weekly strength training sessions per week during the transition period and 10k finish time was -0.039 which was not significant \( (p = 0.807) \).

\[ c. \quad \text{During the competition period.} \]

The Pearson product moment correlation between the average number of weekly strength training sessions per week during the competition period and 10k finish time was -0.244 which was not significant \( (p = 0.120) \).

\[ d. \quad \text{During the peak period.} \]

The Pearson product moment correlation between the average number of weekly strength training sessions per week during the peak period and 10k finish time was 0.147 which was not significant \( (p = 0.354) \).

\[ e. \quad \text{During the entire season.} \]

The Pearson product moment correlation between the average number of weekly strength training sessions per week during the entire season and 10k finish time was 0.138 which was not significant \( (p = 0.383) \).

22. What is the relationship between average number of weekly of drill and form training sessions per week and performance at the 2008 NCAA Championship meet amongst male 10k finishers:

\[ a. \quad \text{During the summer period.} \]

The Pearson product moment correlation between the average number of drill or form sessions per week during the summer period and 10k finish time was 0.014 which was not significant \( (p = 0.929) \).

\[ b. \quad \text{During the transition period.} \]
The Pearson product moment correlation between the average number of drill or form sessions per week during the transition period and 10k finish time was 0.340 which was significant \( p = 0.027 \) and indicates that respondents who performed more drill or form sessions during the transition period ran slower at the NCAA championship race.

c. During the competition period.
The Pearson product moment correlation between the average number of drill or form sessions per week during the competition period and 10k finish time was 0.036 which was not significant \( p = 0.821 \).

d. During the peak period.
The Pearson product moment correlation between the average number of drill or form sessions per week during the peak period and 10k finish time was 0.174 which was not significant \( p = 0.269 \).

e. During the entire season.
The Pearson product moment correlation between the average number of drill or form sessions per week during the entire season and 10k finish time was 0.195 which was not significant \( p = 0.215 \).

23. What is the relationship between average weekly sessions of core training and performance at the 2008 NCAA Championship meet amongst male 10k finishers:

a. During the summer period.
The Pearson product moment correlation between the average number of weekly core training sessions per week during the summer period and 10k finish time was 0.259 which was not significant \( p = 0.098 \).

b. During the transition period.
The Pearson product moment correlation between the average number of weekly core training sessions per week during the transition period and 10k finish time was 0.237 which was not significant \( p = 0.130 \).

c. During the competition period.
The Pearson product moment correlation between the average number of weekly core training sessions per week during the competition period and 10k finish time was 0.191 which was not significant (p = 0.225).

d. During the peak period.
The Pearson product moment correlation between the average number of weekly core training sessions per week during the peak period and 10k finish time was 0.265 which was not significant (p = 0.090).

e. During the entire season.
The Pearson product moment correlation between the average number of weekly core training sessions per week during the entire season and 10k finish time was 0.284 which was not significant (p = 0.069).

24. What is the relationship between minutes spent flexibility training per week and performance at the 2008 NCAA Championship meet amongst male 10k finishers:

a. During the summer period.
The Pearson product moment correlation between minutes spent on flexibility training per week during the summer period and 10k finish time was 0.272 which was not significant (p = 0.081).

b. During the transition period.
The Pearson product moment correlation between minutes spent on flexibility training per week during the transition period and 10k finish time was 0.301 which was not significant (p = 0.053).

c. During the competition period.
The Pearson product moment correlation between minutes spent on flexibility training per week during the competition period and 10k finish time was 0.255 which was not significant (p = 0.102).

d. During the peak period.
The Pearson product moment correlation between minutes spent on flexibility training per week during the peak period and 10k finish time was 0.272 which was not significant (p = 0.081).

e. During the entire season.

The Pearson product moment correlation between minutes spent on flexibility training per week during the entire season and 10k finish time was 0.282 which was not significant (p = 0.071).

25. What is the relationship between average weekly days of rest or without running, not due to injury, and performance at the 2008 NCAA Championship meet amongst male 10k finishers:

a. During the summer period.

The Pearson product moment correlation between the average number of days per week of rest during the summer period and 10k finish time was -0.039 which was not significant (p = 0.804).

b. During the transition period.

The Pearson product moment correlation between the average number of days per week of rest during the transition period and 10k finish time was -0.004 which was not significant (p = 0.978).

c. During the competition period.

The Pearson product moment correlation between the average number of days per week of rest during the competition period and 10k finish time was 0.035 which was not significant (p = 0.826).

d. During the peak period.

The Pearson product moment correlation between the average number of days per week of rest during the peak period and 10k finish time was -0.084 which was not significant (p = 0.597).

e. During the entire season.
The Pearson product moment correlation between the average number of days per week of rest during the entire season and 10k finish time was -0.038 which was not significant (p = 0.813).

26. What is the relationship between **days unable to run due to injury or illness** and **performance at the 2008 NCAA Championship meet amongst male 10k finishers:**

   a. **During the summer period.**

   The Pearson product moment correlation between the total days unable to run due to injury or illness during the summer period and 10k finish time was 0.026 which was not significant (p = 0.869).

   b. **During the transition period.**

   The Pearson product moment correlation between the total days unable to run due to injury or illness during the transition period and 10k finish time was -0.097 which was not significant (p = 0.540).

   c. **During the competition period.**

   The Pearson product moment correlation between the total days unable to run due to injury or illness during the competition period and 10k finish time was -0.025 which was not significant (p = 0.875).

   d. **During the peak period.**

   The Pearson product moment correlation between the total days unable to run due to injury or illness during the peak period and 10k finish time was -0.066 which was not significant (p = 0.676).

   e. **During the entire season.**

   The Pearson product moment correlation between the total days unable to run due to injury or illness during the entire season and 10k finish time was -0.054 which was not significant (p = 0.734).
CHAPTER FIVE: DISCUSSION

This research was conducted to gain further insight into how the best NCAA cross country runners currently train and if any certain methods are more beneficial or detrimental than others in relation to performance at the 2008 NCAA championship 10k race. Few studies of this nature have been conducted in the past (Karp, 2007; Kurz, Berg, Latin, & deGraw, 2000; Bale, Bradbury, & Colley, 1986) as most running research has been focused on the short term, with a very small sample size, and a focus on physiological changes and not race performance (Billat, Demarle, Slawinski, Paiva, & Koralsztein, 2001; Craib, Mitchell, Fields, Cooper, Hopewell, & Morgan, 1996; Pate, Macera, Baily, Bartoli, & Powell, 1992; Acevedo & Goldfarb, 1989; Berg, Olson, McKinney, Hofschire, Latin, & Bell, 1989; Morgan, Baldini, Martin, & Kohrt, 1989).

As previously stated, the lack of participation must be considered a major limitation to this research. Because only 42 out of 252 possible subjects (17%) completed the survey, the statistical power and generalizability to all runners of this study is diminished. It cannot be assumed that the conclusions would hold true for all NCAA Division I runners although the distribution of the participation based on place and 10k finish time, though, does suggest that results are not skewed in one direction. Also, since all coaches were contacted in the same method and all athletes had the same opportunity to participate, response rate should be considered independent and random.

Anthropometric and Running History Variables

The anthropometric variables of age, height, weight, B.M.I., year in school, and years of training show no significant findings. Due the nature of distance running and the NCAA eligibility rules, the sample is of young (ages 18-23 years old) and thin (16.27-22.89 kg/m²) males. According to the Centers for Disease control website, a B.M.I. is considered normal if between 18.5kg/m² and 24.9kg/m² which indicates that this sample ranges from underweight to the low end of normal for healthy adults (Healthy Weight:
Assessing your weight, 2009). Number of years running and year in school showed low and not significant (P > 0.05) correlations which is in contrast to some research (Bale, Bradbury, & Colley, 1986) and similar to others (Karp, 2007; Billat, Demarle, Slawinski, Paiva, & Koralsztein, 2001).

The most significant predictor to performance, though, were the pre-college baseline performance times which show that more talented runners ran better at the championship race, despite several more years of training since entering college for many of the respondents. The significant (p < 0.05) Pearson product moment correlations between pre-college 1500/1600 meter times (r = 0.369), pre-college 3000/3200 meter times (r = 0.319), and pre-college 1500/1600 meter plus 3000/3200 meter times (r = 0.377) show that even amongst a small population with very similar pre-college performance times (0.55 min range for 1500/1600 meter times, 1.81 min range for 3000/3200 meter times, and 1.99 min range for the composite pre-college times variable), having better baseline performance times does increase performance in future races. This information can be disheartening for athletes trying to improve, as it can be interpreted that a person’s potential is shown at an early age, before 18 years of age. Lastly, and most prominently, these results also show that collegiate coaches who can recruit faster pre-college runners are more likely to have more success.

Training Progression

Training programs for NCAA cross country teams are set by the coaches. Each period of the season is carefully set to allow the runners to run fastest at the NCAA championship 10k race in November of each year. The principle of progressive overload, or a slow increase in training, has been documented by both Karp et al. (2007) and Kurz et al. (2000) in regards to training for distance running. Karp noted that male marathon runners from the 2004 U.S. Olympic Trials ran significantly (p < 0.05) more kilometers per week at tempo and marathon pace during the later quarters of the year, closest to the trials race. Although Kurz et al. (2000) did not calculate the significance, it was reported that mileage (59.5±10.6 vs 72.4±9.1 miles per week), repetition training
(0.1±0.3 vs 0.7±0.6 sessions per week), interval training (0.1±0.3 vs 0.8±0.6 sessions per week), and practice held twice a day (1.5±1.9 vs 3.5±1.5 two-a-day practices per week), increased from the transition phase (May, June, July and August) to the competition phase (September and October) amongst NCAA cross country teams that participated in the study. These past results are consistent with the findings in current research.

The current data shows training for runners in the study progressed throughout the season. The least amount of training in regards to volume, intensity, and ancillary training seems to be in the summer period while the competition period is the most strenuous. Coaches are most likely building the runners training base during the summer period and slowly increasing training levels through the competition period, where training is the highest.

The training concept known as tapering is also evident in this data. Tapering is defined as a period of decreased training the weeks before an important competition in order to enhance physical performance (Houmard, Scott, Justice, & Chenier, 1994). Although most training variables do not decrease to summer period levels, many decrease during the peak period. One variable that actually increases each period throughout the season is the number of repetition training sessions per week. This variable increases each period during the season and peaks during the peak period. The increase in repetition training is most likely due to the fact that physiological predictors of performance, such as VO$_{2\text{max}}$, anaerobic power, and speed, can be improved more quickly with repetition training (Helgerud, et al., 2007; Dawson, Fitzsimons, Green, Goodman, Carey, & Cole, 1998; Sinnett, Berg, Latin, & Noble, 2001). Since repetition training does not require large amounts of time to see the benefits and it may not fatigue runners as much as other training variables do, it is a good training method while trying to taper and peak for the NCAA regional and championship races.
Analysis of Training Variables

It is interesting to compare the use of each training variable to one another. Although not a statistical comparison it seems evident that amongst high intensity training methods threshold and interval training are utilized more often than repetition, fartlek, and hill training (figure 10). This is consistent with previous research. Bale et al. (1986) reported that amongst twenty elite runners, they ran 16.5% of their total mileage as fast runs (similar to threshold training), 21.5% as interval runs, while only 2.5% as fartlek runs. Perhaps coaches believe interval and threshold training methods are superior training methods to other high intensity training as they best prepare runners for the 6.2 mile race. Previous research has shown that interval and threshold training increase time and distance to exhaustion (Philip, Macdonald, Carter, Watt, & Pringle, 2008; Billat, Sirvent, Lepretre, & Koralsztein, 2004). These findings also meet the recommendation by Billat et al. (1999) that one interval session at VO_{2max} with one at the lactate threshold per week is sufficient to increase VO_{2max} and vVO_{2max} in runners.

Figure 10. Use of selected run training variables throughout the season.

When comparing volume variables, such as mileage, number of runs per week, long run distance, and days of rest, all show that coaches progress the volume of
training though the competition period. Weekly mileage, number of runs per week, and long run distance all increase from summer to the competition period while rest decreases from 1.09±1.45 days during the summer period to less than 0.5 days for the transition, competition and peak periods.

It is also evident that runners in this study are training at slightly a higher volume of miles per week than runners from the Kurz et al. (2000) study. In the Kurz et al. (2000) research, NCAA coaches from 1996 responded that his/her team peaked in September and October at 72.4±9.1 miles per week while runners in the current study reported their peak at 80.2±13.9 miles, also in the same time frame. In November, during the peaking period, Kurz et al. (2000) respondents stated that weekly mileage averaged 58.9±10.3 while the current research shows that runners averaged 68.3±11.9 miles per week. Although no statistical tests were done, it is evident that NCAA runners are currently running more mileage. Training at a high volume of mileage is a current trend with the recent success of high mileage programs such as the University of Colorado as reported in the popular running book Running with the Buffaloes (Lear, 2003).

The days missed due to injury variable also needs more explaining. The respondents missed an average of 2.48±7.15 days due to injury during the summer period. This is mainly because three runners (7%) missed between 25 and 30 days due to injury while only seven others (17%) missed seven days or less due to injury as the majority (n = 32, 76%) were healthy and did not miss any time during the summer period. During the transition phase, two runners missed 10 and 15 days respectively while nobody else missed more than three days as the average days missed due to injury were less than 1.5 for the transition, competition, and peak periods. This shows that some runners may be able to miss some training in the summer and still get enough training during the rest of the season to qualify for and perform well at the NCAA championship meet, but most need to be healthy for a large majority of the season in order to succeed during the NCAA cross country season.
Significant Correlations

Very few significant ($p < 0.05$) correlations between training variables and performance at the NCAA championship 10k race were found (table 21). This is consistent with previous research. Research by Karp (2007) on U.S. Olympic Marathon Trials participants reported that “none of the [collected] training variables were a significant predictor of marathon performance for men.” He concludes that “either multiple factors might be responsible for men’s marathon performance or that there simply was too much variability in the data to predict marathon performance.” Kurz et al. (2000) reported a few correlations to performance. They found that repetitions, intervals, fartlek and practice held twice a day during the transition phase (May, June, July, August) and intervals and fartlek during the competition phase had a significant ($p < 0.05$) and moderate correlation to slower mean team time amongst 14 teams at the 1996 NCAA cross country championships while tempo training during the peaking phase (November) was related to faster team times.

Table 21. Variables with significant ($p < 0.05$) correlations to performance ($n = 42$).

<table>
<thead>
<tr>
<th>Variable</th>
<th>Min</th>
<th>Max</th>
<th>Mean</th>
<th>S.D.</th>
<th>$r^*$</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pre-College 1600 meter time (min)</td>
<td>4.00</td>
<td>4.55</td>
<td>4.27</td>
<td>0.12</td>
<td>0.369*</td>
</tr>
<tr>
<td>Pre-College 3200 meter time (min)</td>
<td>8.59</td>
<td>10.40</td>
<td>9.25</td>
<td>0.35</td>
<td>0.319*</td>
</tr>
<tr>
<td>Pre-College 1600m plus 3200m times (min)</td>
<td>12.59</td>
<td>14.58</td>
<td>13.53</td>
<td>0.42</td>
<td>0.377*</td>
</tr>
<tr>
<td>Form/Drill Sessions During The Transition Period</td>
<td>0.00</td>
<td>5.00</td>
<td>1.03</td>
<td>1.17</td>
<td>0.340*</td>
</tr>
<tr>
<td># Threshold Training Sessions During the Peak Period</td>
<td>0.00</td>
<td>3.00</td>
<td>0.93</td>
<td>0.61</td>
<td>0.309*</td>
</tr>
</tbody>
</table>

*The Pearson product moment correlation to the dependent variable of 10k finish time.
+Correlation is significant at the 0.05 level (2-tailed).

This current research shows that other than previous performance times, only the number form/drill sessions during the transition period and threshold training sessions significantly ($p < 0.05$) correlate to performance amongst the respondents. Both of these training variables had a moderate correlation to a slower performance time. Form/drill sessions could lead to slower times as it is possibly substituted for other, more important training methods, and perhaps it is not appropriate to perform more than one or two sessions per week for performance.
The correlation of threshold training sessions during the peak period to slower performance is in contrast the 1996 study by Kurz et al. (2000) which reported that tempo training during the peaking phase had an $R^2$ value of 37.2 which was significant at the 0.05 level. In the 12 years between the studies, it is interesting that despite low numbers of significant ($p < 0.05$) correlations between training variables and performance in both studies that these findings contradict each other. In the review of literature, it was noted that threshold training has been shown to increase time and distance to exhaustion (Philip, Macdonald, Carter, Watt, & Pringle, 2008; Billat, Sirvent, Lepretre, & Koralsztein, 2004). Threshold training, which is faster up-tempo running designed to increase the lactate threshold and act as a race simulation, just slower than race pace (Daniels, 2005) could cause the runner to get too comfortable at a reduced pace or lead to too much fatigue during the peak period. Runners performing threshold training just before the championship race therefore may either naturally settle into a slower race pace or be too fatigued from the training to maintain a faster one.

**Multiple Regression Analysis**

The multiple regression analysis results show that the composite pre-college 1500/1600 meter plus 3000/3200 meter times is the best predictor of performance at the NCAA championship meet amongst the respondents. As discussed before, this variable is closely related to a runners baseline talent level and shows that more talented pre-college runners develop into more successful collegiate runners. This finding is as expected as it has previously been reported that past personal best times are good predictors of current performance (Karp, 2007).

When all variables were entered into the stepwise multiple regression equation, other than the composite pre-college times variable, the number of core sessions during the peak period and number of form/drill sessions during the transition period are the only other variables included in the stepwise model as significant ($p < 0.05$). These variables are usually seen as ‘extra’ training that runners can add to running training for small improvements in performance or injury prevention. Possibly some runners spend
too much time on the ‘extra’ training of core and form/drill exercises instead of adding more specific run training or resting. Also, instead of resting for the next running workout, some runners may be adding ‘extra’ training when it is not necessary. This could be hindering full recovery and hurting future run training. In either case, this is an indication that too much ‘extra’ training can be detrimental to performance if not performed appropriately.

When only entering the running variables into the stepwise multiple regression equation, the only variable that was entered as significant (p < 0.05) was the number of threshold training sessions during the peak period. Performing more threshold sessions during the peak period indicated a slower 10k finish time and explained 7.3% of the variance of the 10k finish time. As discussed previously, perhaps this training, at just slower than race pace either causes too much fatigue or allows the runners to get too comfortable at a slower pace which was difficult to increase during the NCAA championship race. Although no run training variables, during the stepwise multiple regression or Pearson product moment correlation analysis, indicated faster performance at a significant (p < 0.05) level, these results suggest that threshold training should be limited during the peaking period before the championship race.

Conclusions

The major finding of this research is that better pre-collegiate runners become better collegiate runners. Coaches should recognize that recruiting better runners is most likely the best and quickest way to improve their team. Individuals, hopefully, though will continue to run competitively despite slower pre-collegiate performance times as many exceptions to this finding are evident. It appears also that coaches and runners as part of NCAA cross country teams do understand and utilize the principles of progression, overload, and tapering as this is very evident in the data. Starting out at a lower volume and intensity of training, increasing throughout the season, and lastly tapering in the weeks before the championship race seem to be the popular method of training. Runners are running more than in the past and favoring threshold and interval
workouts over repetition, fartlek, hill workouts. An excess amount of threshold training just before the championship race may lead to poorer performance from excess fatigue or inability to increase running pace for the race. Ancillary training, especially core and form/drill training, should be carefully monitored so as to not cause excess fatigue and hinder future running workouts as they may lead to overtraining and poorer performance.

The lack of multiple significant (p < 0.05) correlations to performance was not an unexpected result of this research. These findings show that training for high level competition, specifically running, is more than just performing one specific training method. The combination of all training methods, volume, intensity, and ancillary training is what is going to allow a runner perform best. Overall, training programs need to be viewed like a puzzle, as coaches and runners must determine which methods fit with each individual, when they should done, how often to perform them, and at what intensity. Training has become very complicated and the coach that can put all the pieces together to fit his/her athletes the best will most likely have the most success.

**Suggestions for Future Research**

It has been stated many times that there is much research of a short nature, with small sample sizes that focus on the physiological determinates of performance. It would be most beneficial to keep the sample sizes larger, increase the time frame of the studies, and keep the focus on high level runners. Since performance is most important for athletes, physiological testing should be done in conjunction with races or performances. On the NCAA level, it would be interesting to track the better runners training and performances throughout their entire academic year or even collegiate career to describe current training methods and relationships to performances. Looking outside the NCAA, comparing training methods utilized by Americans to those used by those of other nationalities could also produce exciting results. Running performance research, though, should focus on the elite with a large time frame.
Bibliography


Appendix A

2008 NCAA cross country championships individual and team results for men

Team results


Individual results


61. Glenn Randall, Dartmouth, 30:34.0; 62. Timothy Ritchie, Boston College, 30:34.7; 63. Tyson David, Alabama, 30:34.9; 64. Richard Medina, Colorado, 30:35.3; 65. Pat Sovacool, Miami (Ohio), 30:35.8; 66. Kenny Klotz, Oregon, 30:35.8; 67. Jake Morse, Texas, 30:36.5; 68. Ciaran O’Lionard, Michigan, 30:37.1; 69. Patterson Wilhelm, William & Mary, 30:38.1; 70. Ryan Collins, Virginia, 30:38.4.


81. Kyle Dawson, Penn St., 30:45.2; 82. Jacob Gustafsson, BYU, 30:45.6; 83. Dan Busby, Syracuse, 30:46.0; 84. Zac Hine, Cornell, 30:46.2; 85. Daniel Roberts, Florida St., 30:47.2; 86. Kelly Spady, Washington, 30:47.2; 87. Mark Davidson, Tulsa, 30:47.5; 88. Jason Weller, Iona, 30:48.2; 89. Laef Barnes, UCLA, 30:48.7; 90. Craig Miller, Wisconsin, 30:49.3.


111. Lee Carey, Providence, 31:00.3; 112. Elliott Heath, Stanford, 31:00.4; 113. Drew Shackleton, UCLA, 31:00.5; 114. Vince McNally, Penn St., 31:00.9; 115. Kenyon Neuman, Colorado, 31:01.6; 116. Matt Lemon, Dayton, 31:02.2; 117. Michael Krisch, Georgetown,
101. Andrew Kirwa, Alabama, 31:02.3; 118. Jean-Pierr Weerts, Auburn, 31:02.9; 120. Chris Pannone, Colorado, 31:03.5.


Appendix B

Initial e-mail sent on November 25, 2008

November 25, 2008

Distance Running Training Methods

Dear Coach Ereng:

Congratulations on your success during the 2008 NCAA cross country season. Qualifying runners for the NCAA championship meet is an accomplishment that deserves praise.

I am currently a graduate student in the Health and Human Performance department at the University of Montana working on my master’s thesis. To complete this research, I need to gather training information from as many male finishers of the 2008 NCAA Championship meet as possible. The goal is to summarize training methods of the faster NCAA male cross country runners and determine if there are training patterns related to better performance at the 2008 NCAA Championship 10k race.

If you are willing to let your athletes participate, please direct your male athletes that participated in the 2008 NCAA Cross Country Championships to the following website: http://itoselect.ito.umt.edu/TakeSurvey.aspx?SurveyID=ll2J968
You could either forward this e-mail to them or give them a printed copy of the attached directions.

The online survey is anonymous and all answers will be kept private and confidential. Runners will not be asked to provide any personal information or to answer any questions that could lead to NCAA or legal infractions. They will only be questioned on anthropometric variables, running history, and training methods. I, along with my advisor, Dr. Tucker Miller, will have the lone access to individual surveys. Only averaged and analyzed data will be reported for publication or presentation at a conference. For your information, attached is a hard copy version of the survey.

Thank you for participating in this research. My goal, to compare training methods to performance, will hopefully give all coaches and runners an opportunity to improve training and further the knowledge of current training practices. Although this survey is being completed as my thesis research as a requirement for my master’s degree, I hope to submit the results for publication and possibly present at a conference after completion. Please feel free to contact me if you have any questions or would like a final copy of the results. Good luck during the 2009 track & field season and thank you for passing this information on to your team!

Sincerely,

Philip Keller
Graduate Student, Health and Human Performance
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"Somewhere in the world someone is training when you are not. When you race him, he will beat you." Tom Fleming’s Boston Marathon training sign on his wall.
Appendix C

Sample letter mailed to coaches on December 2, 2008

December 2, 2008

Dear Coach Cole:

Congratulations on your success during the 2008 NCAA cross country season. Qualifying runners for the NCAA championship meet is an accomplishment that deserves praise. You recently received this letter through the e-mail, but to increase participation, I also have mailed you the directions for distribution to your team. If you already directed your athletes to the survey, thank you for doing so and please continue to encourage them to participate. If not, I ask that you do so at this time.

I am currently a graduate student in the Health and Human Performance department at the University of Montana working on my master’s thesis. To complete this thesis research, I need to gather training information from as many male finishers of the 2008 NCAA Championship meet as possible. The goal is to summarize training methods of the faster male NCAA cross country runners and determine if there are training patterns that are related to better performance at the 2008 NCAA Championship 10k race.

If you are willing to let your athletes participate, all I request you do is direct your male athletes that participated in the 2008 NCAA Cross Country Championships to the following website:


Please distribute the enclosed directions to your male athletes and encourage them to take the time (approximately 15 minutes (25 questions)) to fill out the survey.

The online survey is anonymous and all answers will be kept private and confidential. Runners will not be asked to provide any personal information or to answer any questions that could lead to NCAA or legal infractions. They will only be questioned on anthropometric variables, running history, and training methods. My advisor and I will have the only access to individual surveys. Only averaged and analyzed data will be reported for publication or presentation at a conference. For your information, enclosed is a hard copy version of the survey.

Thank you for participation in this research. My goal, to compare training methods to performance, will hopefully give all coaches and runners an opportunity to improve training and further the knowledge of current training practices. Although this survey is being completed as my thesis research as a requirement for my master’s degree, I hope to submit the results for publication and possibly present at a national conference after completion. Please feel free to contact me if you have any questions or would like a final copy of the results. Good luck during the 2009 track & field season and thank you for passing this information on to your team!

Sincerely,

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Appendix D

Directions sent for each runner mailed on December 2, 2008

NCAA Distance Running Training Methods Survey
Directions for Participants

Congratulations on your recent success during the 2008 cross country season. Qualifying for the NCAA Championships is an accomplishment in itself and deserves praise.

I am currently a graduate student in the Health and Human Performance department at the University of Montana working on my master’s thesis. To complete this research, I need to gather training information from as many male finishers of the 2008 NCAA Championship meet as possible. **My goal is to summarize training methods of the faster male NCAA cross country runners and determine if there are training patterns that related to better performance at the 2008 NCAA Championship 10k race.**

I recently contacted your coach to distribute these directions to you. If you could follow these simple directions and take the online survey, it would be greatly appreciated. The online survey is anonymous and all answers will be kept private and confidential. You will not be asked to provide any personal information or to answer any questions that could lead to NCAA or legal infractions. You will only be questioned on anthropometric variables, running history, and training methods. My advisor and I will have the only access to individual surveys. Your coaches will not see any of the information that you provide. Only averaged and analyzed data will be reported for publication or presentation at a conference; no individual data will be reported.

Directions:

- Only male runners who finished the 2008 NCAA Cross Country Championships 10k, as a team or individually, can participate in this survey.
- If you kept a training log during the season, it may be helpful to have it available when answering the questions.
- Follow all directions and read all definitions when answering the questions.
- It should only take 15 minutes to complete the survey.
- Please be as honest and accurate as possible when answering the questions.
- If you feel that you cannot provide accurate information, do not participate.
- Remember that all information will be kept confidential and private.

Please feel free to contact me at anytime if you have any questions.

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Appendix E

Sample survey mailed with letter on December 2, 2008

NCAA Distance Running Training Methods Survey


Directions

Congratulations on your successful 2008 cross country season. Thank you very much for taking the time to fill out the following survey on your preparation for the 2008 cross country season. This survey will provide data for my Master's thesis at the University of Montana. The purpose of this research is to assess the relationships between training variables and performance. Here are a few things to keep in mind while answering these questions:

- This survey should only take approximately 15 minutes (25 questions).
- Please be honest while answering questions.
- You may want to reference your training log for many of the questions.
- The survey is anonymous and all answers will be kept confidential.
- Questions will be asked only on running history, physical characteristics, and training.
- You will not be asked to provide any personal information or to answer any questions that could lead to NCAA or legal infractions.
- The only data that will be reported for publication or presentation will be averaged. No individual survey data will be reported.
- You must have finished the 2008 NCAA Cross Country Championship 10k race to participate.

1. What individual place did you finish in at the 2008 NCAA Cross Country Championships 10k?

2. What was your time, in minutes and seconds, at the 2008 NCAA Cross Country Championship 10k race?

3. What age were you on the day of the 2008 NCAA Cross Country Championships (November 24, 2008)?

4. In inches, how tall are you?*

5. What is your weight in pounds?*

Running History Section

These questions ask about your running history.

For pre-collegiate personal records, only list one time for each question. If you did not run either of the races, then leave those questions blank.

6. How many years have you been running and training competitively?*

*This includes middle school, high school and college running.

7. Prior to enrollment in college, what was your 1500 or 1600 meter personal record time?

8. Prior to enrollment in college, what was your 3000 or 3200 meter personal record time?

Training History Section
Please answer the following training questions as honestly as possible.

These questions refer to the training that you completed while preparing for the 2008 cross country season.

Example: If you perform an interval workout every other week answer 0.5 in that blank. If you perform an interval workout every week during the period, answer 1.

Periods:

<table>
<thead>
<tr>
<th></th>
<th>Summer</th>
<th>Transition</th>
<th>Competition</th>
<th>Peak</th>
</tr>
</thead>
<tbody>
<tr>
<td>Periods</td>
<td>May/June</td>
<td>July/August</td>
<td>September/October</td>
<td>November</td>
</tr>
</tbody>
</table>

9. How many miles did you run on average per week during each period?*

10. How many runs did you perform per week?*
   *Include all runs separated by a minimum of one hour of inactivity or non-running activity.

11. What is the length in miles of your longest single run during each period?

12. How many sessions of tempo or threshold training did you perform on average per week during each period?*
   *Definition: Longer runs that are run slightly slower than current race pace often used to increase endurance and stress the lactate-clearance capability.
   *If you perform a tempo/threshold workout every other week answer 0.5 in that blank. If you perform a tempo/threshold workout every week during the period, answer 1.

13. How many sessions of interval training did you perform on average per week during each period?*
   *Definition: Repeated bouts of hard running at speed near race pace with a recovery period no longer than the running period. Interval training includes longer bouts than repetition training such as 1000 meter intervals, mile intervals, 5 minute intervals, etc.
   *If you perform an interval workout every other week answer 0.5 in that blank. If you perform an interval workout every week during the period, answer 1.

14. How many sessions of repetition (speed) training did you perform on average per week during each period?*
   *Definition: Very fast running bouts followed by a full recovery whose purpose is to increase speed and economy of running. These are shorter and faster running bouts than interval training such as 100 meter, 200 meter, 400 meter repeats with extended recovery.
   *If you perform a repetition workout every other week answer 0.5 in that blank. If you perform an repetition workout every week during the period, answer 1.

15. How many sessions of fartlek training did you perform on average per week during each period?*
   *Definition: A Swedish term defined as “speed play” that indicates a type of interval or repetition training which combines varying speeds, times, and distances. These are different from interval and repetition sessions as they combine different paces and distances. Examples may include ladders or varied pace workouts.
   *If you perform a fartlek workout every other week answer 0.5 in that blank. If you perform a fartlek workout every week during the period, answer 1.

16. How many sessions of hill training did you perform on average per week during each period?*
   *Definition: Includes any training that involves the use of running up hills at a high intensity followed by rest periods.
   *If you perform a hill workout every other week answer 0.5 in that blank. If you perform a hill workout every week during the period, answer 1.

17. How many collegiate cross country races did you compete in during each period?

**Ancillary Training Section**

Answer each question honestly.
These questions refer to the non-running training that you completed while preparing for the 2008 cross country season.

Answer in average sessions per week during each period.

18. How many sessions of cross training did you average per week during each period?*
   *Definition: Any endurance training that is not running. This may include bicycling, swimming, pool running, Nordic skiing, or eliptical training.

19. How many minutes did you spend on flexibility training per week during each period?*
   *Definition: All types of stretching techniques including ballistic stretching, passive stretching, contract-relax stretching, and static stretching.

20. How many sessions per week of strength training did you average during each period?*
   *Definition: Training with the use of weights, or body weight exercises, designed to increase strength and reduce injuries.

21. How many sessions per week of speed/form drill and plyometrics did you average during each period?*
   *Definition: Designed to improve running form, efficiency, power, acceleration, and speed. They may include jumping, hopping, and bounding movements designed to improve power or running form.

22. How many sessions per week of core training did you average during each period?*
   *Definition: Training specifically designed to increase strength in the core region of a runner. This includes sit-ups, crunches, leg raises and isometric planks.

23. How many days per week of rest without running did you average during each period?*
   *Definition: These only include planned days of rest with no running. Do not include days missed due to injury or illness.
   *If you have 1 day of rest, with no running, every 2nd week, answer 0.5 for that period. If you take one day per month off, answer 0.25 for that period.

24. How many total days during each period were you unable to run due to injury or illness?*
   *Times when you were unable to perform at least 50% of the set running workout of that day.

25. If you have any need for clarification or would like to leave comments, feel free to do so in this box.
Appendix F

E-mail sent to coaches on December 12, 2008

Subject: Help needed on thesis research

Dear Coaches,

Hello, my name is Phil Keller and I am graduate student at the University of Montana. Recently you should have received some information from me. First an e-mail and more recently a letter concerning my thesis research on distance running training methods.

I am trying to perform an online survey on male NCAA cross country championship finishers about their training during the 2008 season. So far, the response has been very low, as only 12 out of 252 finishers have completed the survey. In order for me to complete my thesis and perform a meaningful study, I need at least 100 participants.

I ask that you, as coaches and teachers, help me out in my quest to study the relationships between training components and performance. All that you need to do is direct your athletes to the website below and ask that they take 10-15 minutes to complete the survey. I can assure you that the information will stay anonymous and confidential, as only averaged data will reported. No individual results will be reported or posted anywhere!

My goals are to complete this thesis and possibly be published and/or present at a national conference. I only hope to better the training of cross country runners to help future performance. If any coaches want a copy of my final report, I would love to e-mail or mail anyone a copy.

I am a runner and coach myself and hope one day to join your ranks as a collegiate coach. I appreciate the work that coaches do as teachers and leaders of athletes, helping their team become better runners and better people as my coaches have been instrumental in my life.

I appreciate your help in my thesis research, especially those that have already directed their athletes to the survey.

Attached is a hard copy of the survey and directions for the runners.

The online survey is located at: http://itoselect.ito.umt.edu//TakeSurvey.aspx?SurveyID=Il2J968

Sincerely,

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"Somewhere in the world someone is training when you are not. When you race him, he will beat you."
Tom Fleming’s Boston Marathon training sign on his wall.
Appendix G

E-mail sent of January 27, 2009 to coaches

Subject: NCAA Training Methods Survey

Dear Coaches,

Now that all schools are in full swing and the indoor season has officially begun, I am going to ask you one last time to help me with my Master's research project on training methods for a NCAA cross country season. **Currently, only 36 runners have filled out the online survey (out of 252 male NCAA CC Championship Finishers).** All I ask, is that you encourage your runners that competed in the NCAA CC Championship 10k to fill out the online survey. Again, I am doing this as part of my Master's thesis, would like to publish the results in a professional journal, and present at a national conference. The survey is completely anonymous and will only take 10-15 minutes of your athletes time.

The link to the survey is:


As per my thesis contract, I am going to contact each coach via phone in the next two weeks to again ask for participation and a couple of questions regarding the ease of the survey for you and your athletes; **the phone call will be my last contact and request for help.** Thank you to those coaches and teams that have taken the time to help further the research of distance running and complete the survey. Feel free to contact me anytime via e-mail or telephone if you have any questions.

Good luck in indoor track & field!

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"Somewhere in the world someone is training when you are not. When you race him, he will beat you."
Tom Fleming's Boston Marathon training sign on his wall.
Appendix H

E-mail sent to coaches on March 12, 2009

Subject: Training Methods Study – Final E-mail

Dear Coaches,

Thank you to the coaches that encouraged their team to fill out my online survey on distance running training methods. Unfortunately, I only had a response rate of 43 out of 252 NCAA Cross Country male finishers. The survey is still open at the link below, so athletes can still fill it out, but for the purpose of my thesis, I need to determine why, as best as possible, I did not get a good response rate to include in my defense for graduation.


If you could take a minute to reply with answers to the following five questions, it would be much appreciated. Those that do not reply via e-mail, I will try to contact via telephone. Thanks again for your help; this will be the last time I e-mail you unless you requested the results.

1) Did you give the link to the survey to your athletes?
2) If yes, how? E-mail, printed directions, other?
3) If no, why not?
4) Was there any confusion with the directions or the survey in general that you are aware of?
5) Is there a better way survey NCAA distance runners?

Thank you very much for your time and good luck in outdoor track.

Philip Keller
Appendix I

E-mail sent to coaches on April 15, 2009

Subject: Training Methods Study – Questions for Coaches

Dear Coaches (that have not yet responded to questions),

Thank you to the coaches that encouraged their team to fill out my online survey on distance running training methods. Unfortunately, I only had a response rate of 43 out of 252 NCAA Cross Country male finishers which does not have much statistical power. The survey is still open at the link below, and athletes can still fill it out; I encourage you to still send the link to your athletes.


I also need to determine why, as best as possible, I did not get a good response rate to include in my defense for graduation.

If you could take a minute to reply with answers to the following five questions, it would be much appreciated. Thanks again for your help.

1) Did you give the link to the survey to your athletes?
2) If yes, how? E-mail, printed directions, other?
3) If no, why not?
4) Was there any confusion with the directions or the survey in general that you are aware of?
5) Is there a better way survey NCAA distance runners?

I have been trying to contact coaches via telephone but it has been difficult as it everyone is busy traveling for this outdoor track season. If you reply to this e-mail, I will not call you.

Thank you very much for your time and good luck in outdoor track.

Philip Keller

"Somewhere in the world someone is training when you are not. When you race him, he will beat you." Tom Fleming’s Boston Marathon training sign on his wall.
Appendix j


Hello Coach.

My name is Philip Keller. I am currently a graduate student in the Health and Human Performance department at the University of Montana working on my master’s thesis. To complete this thesis research, I need to gather training information from as many finishers of the 2008 NCAA Championship meet as possible. My goal is to summarize training methods of the faster NCAA cross country runners and determine if there are training patterns that related to better performance at the 2008 NCAA Championship 10k race.

Have you received the information that I have sent you via e-mail and mail? Do you have any questions you would like to ask me about this research?

Have you given your athletes the directions to participate in the online survey?

If yes: Thank you for doing that. How did you inform your athletes of the survey? If you could please encourage your runners to complete the survey, it would be greatly appreciated.

If no: Is there a reason that you have not done so? Is there anything that I could do to help you?

Was there any confusion with the directions or the survey in general that you are aware of?

I just want to remind you that the online survey is anonymous and all answers will be kept private and confidential. Runners will not be asked to provide any personal information or to answer any questions that could lead to NCAA or legal infractions. Anthropometric variables, running history, and training questions are all that will be asked. The research committee of four, myself and three university professors, will have the lone access to individual surveys. Only averaged and analyzed data will be reported for publication or presentation. For your information, attached is a hard copy version of the survey.

Do you have any questions about the survey and its confidentiality?

Thank you for your consideration to participate in this research. My goal, to compare training methods to performance, will hopefully give all coaches and runners an opportunity to improve training and further the knowledge of current training practices. Although this survey is being completed as my thesis research as a requirement for my masters degree, I hope to submit the results for publication and possibly present after completion.

Do you have any other questions?

Is there a better way survey NCAA distance runners?

Would you like a copy of my findings e-mailed to you when I am done?

Thank you for your time. Goodbye.
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<th>School</th>
<th>Coach Name</th>
<th># of Runners</th>
<th>Coach's e-mail</th>
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