AN EXAMINATION OF FINISH TIME VARIATION FOR COLLEGIATE CROSS COUNTRY NATIONAL CHAMPIONSHIPS BY GENDER

By

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A thesis

submitted in partial fulfillment

of the requirements for the degree of

Master of Science in Exercise and Sport Studies, Behavioral Studies

Boise State University

December 2012

BOISE STATE UNIVERSITY GRADUATE COLLEGE

DEFENSE COMMITTEE AND FINAL READING APPROVALS

of the thesis submitted by

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Thesis Title: An Examination of Finish Time Variation for Collegiate Cross Country National Championships by Gender

Date of Final Oral Examination: 28 September 2012

The following individuals read and discussed the thesis submitted by student Kevin Riley Peters, and they evaluated his presentation and response to questions during the final oral examination. They found that the student passed the final oral examination.

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ABSTRACT

Variations in Finishing Times for Cross Country

National Championships by Gender

Kevin Riley Peters

In cross country, women compete over shorter distances than men with little justification for these differences. The purpose of this study was to assess gender differences for the spread of finishing times and examine the appropriateness of shorter competition distances for females. Forty-six cross country national championship data sets (n_{males} = 10,788; $n_{females}$ = 10,884) from the NCAA (1999-2011) and NAIA (2005-2011) were utilized for analyses. Several measures of variation were computed to assess spread of finishing times data (i.e., Coefficient of Variation [CV]; Interpercentile Ranges [IR], and Rates of Separation [RS; IR divided by the distance of the race]). Independent *t*-tests revealed significant gender differences on all three measures of variations. Males and females differed on CV (M_{males} = 3.93, *SD* = 1.04; $M_{females}$ = 4.84, *SD* = 1.05, $p < .001$), as well as each percentile range for IR and RS. Specifically, males and females differed on IR for NCAA Division I, $IR_{5th-95th}$ (M_{males} = 194.32; $M_{females}$ = 167.93, p < .001), $IR_{10th-90th}$ (M_{males} = 146.66; $M_{females}$ = 127.51, p < .001), and Division II, $IR_{10th-90th}$ (M_{males} = 237.32; $M_{females}$ = 203.37, p = .001). Males and females also differed on all RSs for all four levels of competition. For women, a race distance at 68.6% of the distance of the men could

generate equivalent variations between genders. Finish times for women's races were more spread out than for men's races when adjusted for distance and time. The spread of finishing times may justify shorter distances run by women.

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CHAPTER ONE: INTRODUCTION

Collegiate cross country competitors run different distances based on gender (National Collegiate Athletic Association [NCAA], 2011; National Association of Intercollegiate Athletics [NAIA], 2011a). At the NCAA Division I championship level, for example, women compete over a 6 km race course and men compete over a 10 km race course. The typical time for women to complete a race at this level is approximately 21 minutes; whereas, for men it takes 31 minutes for a 10 km. The situation is similar at the world championship level where women run 8 km and men run 12 km in 27 minutes and 36 minutes, respectively.

The distance of a race is arbitrary as long as everyone in the race is competing at the same distance. Although men and women do not compete directly against each other, having women compete over a shorter distance and time than men may imply that women are somehow weaker and less capable than men in this sport. As a former collegiate cross country runner and collegiate cross country coach, I have been curious as to why women competed over a shorter distance than men within cross country but no other event in track and field.

Cross country is not the only sport in which women compete at shorter distances. In cycling, at the Olympic and World Championship competitions, women have historically competed on a course roughly half the length of the men (Lucas, 2010). In the

Winter Olympic sport of Luge, for example, men start their race higher up the track than women, generating a longer run for men. Typically, men compete over a 1,300 m track compared to 1,100 m for women (i.e., about 15% shorter; USA Luge, 2010).

When compared to their male counterparts, women have competed over shorter distances or with different rules for a number of reasons. According to historian Cahn (1994), the justifications offered for these differences are that sport is too strenuous for women to compete at the same distance as men; strenuous competition can interfere with women's menstrual cycles; and women will become sexualized if they compete in sport (e.g., women will be viewed as sexual objects). Finally, Cahn suggests if women compete under similar guidelines, it will result in competition between genders.

Although the modern Olympics commenced in 1896, women did not compete in Olympic Track and Field events until 1928. In 1928, women competed in only five events within track and field (i.e., 100 m, 800 m, 4x100 m Relay, high jump, and discus; Cahn, 1994). In fact, Cahn reported that the 800 m was pulled from the women's Olympic program after officials were horrified by a few women collapsing at the end of the 1928 race and not reinstated until 1960. Finally, six decades later at the 1984 Olympic Games in Los Angeles, women competed in the Olympic marathon. In 2008, women had the 3,000 m steeplechase added to the Olympic program making the men's and women's race distances the same on the track.

Reasons as to why women traditionally competed at shorter distances in running events are similar to the justifications given in other sports. Distance events in track and field were thought to damage the women's reproductive organs, promote masculinity, and develop masculine body types; thus, women were not encouraged to participate (Cahn, 1994). Unfortunately, all of these reasons are cited as opinion and not based on any scientific assessments. Hence, more scientific and academically rigorous sources of gender differences may play a role in determining the reasons why males and females should compete in events at different distances.

In addition to shorter competition distances, some governing bodies have instituted modifications to the rules or equipment for women. Softball has a larger ball assumed to be easier to hit and played on a smaller field as compared to baseball (Callaway, 2011). Women in high school and college once played the game of basketball under very different rules than men. For example, women played the game with six players from each team on the court instead of five. The six players consisted of three forwards and three guards. Forwards were required to stay in the front court and play offense, while guards were required to stay in the backcourt and play defense. Only forwards were allowed to shoot the ball. This restriction was modified when two of the six players (i.e., rovers) were allowed to move anywhere on the court. These rule modifications slowly eroded and evolved into males and females competing under similar rules with a smaller basketball in 1987 (Hult & Trekell, 1991). These are only a few of the many examples within sport where women compete under very different rules at a seemingly less demanding standard than men.

These competitive differences between men and women may or may not be justified. Competition differences are legitimate, for example, if those differences encourage higher participation and allow a higher percentage of women or men to be competitive. Males and females have some notable differences. Although males, as a population (Osbourne, 2002), tend to be little bit taller and stronger than females, this difference is not to say that *all* males are taller than *all* females or that *all* males are stronger than *all* females; rather, on average, males are taller and stronger than females. Strength and height can be important factors when it comes to being competitive within sport. It seems legitimate to adapt rules of a sport to the population that is participating within that sport if the differences encourage higher participation or allow a higher percent of the population to be competitive. Therefore, it can be justified for men and women to compete in sport with slight variations to address the needs of each population.

Sport offers numerous examples of men and women competing under different guidelines justified on the basis of physiological differences between women and men. In golf, women begin each hole from a teeing ground closer to the green compared to men (i.e., approximately 10% closer to the hole). In basketball, women use a smaller and lighter ball than men because women generally have smaller hands and are not as strong as men (Osbourne, 2002). Many of the track and field events that utilize equipment (e.g., shot puts, steeplechase) have different requirements based on gender. In the steeplechase, men hurdle a barrier that is three feet high (.91 m), whereas women hurdle a barrier two and one-half feet high (.76 m) or 83% of the men’s height (United States of America track & field [USATF], 2012). These examples provide evidence as to how rules within sports are modified for the population of participants and, therefore, are justified for physiological differences such as height, hand size, and physical strength.

Gender differences have been examined also at the cellular level within exercise physiology where females may experience less cellular damage during exercise (Tiidus, 2000). Theoretically, this difference would mean that females recover faster from endurance exercise than males. Females also have better fat utilization during endurance events than males (Tarnopolsky, 2000). Fat utilization is important for endurance exercise because fat is a late stage fuel the body utilizes for energy. These gender differences actually suggest that women should compete over a longer distance than men, not a shorter distance.

In the field of sport and exercise psychology, gender differences have emerged as to how females and males view sport. Males tend to score higher than females on competitiveness, which suggests males are more motivated to participate in competitive sport (Stevens, Osborne, & Robbins, 2002). This tendency could result in males attempting to compete in distance running in higher numbers than females. Intuitively, if males participate in competitive sport in higher numbers than females, it might be anticipated that male sports would be more competitive and, therefore, more likely to exhibit close contests. Males also tend to score higher than females on win orientation, which suggests males tend to be more focused on the outcome of a competition as it relates to how they performed against other individuals (Stevens et al., 2002).

One might conclude from this finding that males will be more motivated to maintain a given pace longer than females in order to stay with a competitor. In contrast, females tend to score higher than males on goal orientation, which indicates females are more focused on how they performed relative to past performances rather than other participants (Stevens et al., 2002). Given this notion, females may be concerned more with their own performance and allow their competitors to run away from them in a race. Men also tend to contribute more to a group than females when they are in direct competition with another group (Van Vugt, De Cremer, & Janssen, 2007). Given that national cross country meets at the collegiate level are team races, males may tend to give a greater effort than females because they are helping their group to compete against other groups.

Sociocultural concerns are worth considering also when examining gender differences in sport. During adolescence, sport participation drops dramatically for girls but males do not show a corresponding drop in participation (Osborne, 2002). This participation discrepancy may result in fewer female athletes participating once they reach the collegiate level, making it easier for a female of lesser innate ability to compete in college.

Need for the Study

A need exists to assess whether different distances in cross country events for males and females are justified based on finish time variations by gender. Deaner (2006a) found gender differences when he analyzed race times by comparing times from published performance lists (i.e., the best times over a specific distance in a year) to world records. Deaner also found gender differences when those same times were compared to an elite standard called the 10 fastest standards, a standard thought to be less male-biased than the current world records. In addition, Deaner (2006b) analyzed individual road races and found similar gender differences. All analyses showed men to be more competitive than women relative to an elite standard (i.e., more men ran closer to an elite standard than women) based on his analysis of road races. Deaner (2006b) also found that women tend to win races by greater margins than men (i.e., more time elapses between the first and second women's finishers than between the first and second men's finishers); however, Deaner was not interested in how the times within these races compared to all the other times run within the same race. His studies were primarily concerned with the overall competitiveness of each gender and not with how individual races spread apart. If women show a greater finish time variation than men, then the different competition distances appears to be justified because men will require a longer competition distance to spread the field apart.

Given that men and women run different distances, there are two ways this study can be conducted. The first is to ignore the differences in distance and to use absolute measures. The second is to account for the differences in distance and to use relative measures. A relative measure is simply a measure as it relates to another factor; for example, relative VO_2 max is relative to an individual's weight whereas absolute VO_2 max does not take into consideration the individual's weight. Deaner's studies (2006a, 2006b) utilized *relative* measures rather than absolute measures because all of the marks analyzed were reported as times *relative* to an elite standard. Similarly, for cross country race times, a relative measure takes into account the distance of the race and was adjusted by race distance for males (10 km or 8 km) and females (6 km, or 5 km) to allow for comparisons.

Purpose

The purpose of this study was to analyze finish time variations between men and women for college cross country national championships to determine whether gender differences exist. The secondary purpose of this study was to determine statistically appropriate competition distances for men and women with respect to variability of finishing times. The analyses included both relative and absolute comparisons of finish times between men and women. The relative comparison was needed because men and women run different distances. This relative comparison was used to assess whether men and women finished more or less spread apart. The absolute comparison was needed to determine whether the current competition distances were statistically justified for males and females. That is, if men's and women's fields are spread apart equally based on finishing times from the first to the last finishers, then the current competition distances are justified. Additionally, the absolute comparisons were used to determine statistically appropriate competition distances.

The statistically appropriate distances were determined by the overall variation of the finishers by gender. The goal of determining statistically appropriate distances was to generate an overall variation of corresponding men's and women's races as close to equal as possible. This goal was desirable for two reasons: (a) race officials need the fields to be spread apart enough to easily determine finishing order and (b) races should be closely contested in order to make the competitions more interesting for spectators.

Operational Definitions

Absolute Race Measures. There were two absolute race measures utilized in this study. The absolute time for a race is the finisher's actual time without any consideration to the distance run. A runner finishes a race in 27 minutes (i.e., absolute time). This time more than likely would win a Division I men's 10 km race; however, that same time would more than likely finish in last place in a Division I women's 6 km race. The *absolute race measure*, therefore, is the time it took an individual to run a race at a particular distance. It does not allow for comparisons by gender because males and females typically run different distances. In addition to the actual finish times for participants in each race, the other absolute measure was represented as Interpercentile Ranges. The Interpercentile Ranges represent the difference in time between two finishers' actual times or how much time elapsed from when the first of the two finishers finished and the second of the two finished. See "Procedures for Calculation of Variation Variables" in Chapter Three for further explanation.

Relative Race Measures. Relative race measures are more meaningful than absolute race measures when there is a comparison between races of different distances or genders. A relative race measure takes into consideration the inherent difference in distance between races. Specifically, times of a 10 km race and 8 km race will be different because they are different distances. If the overall finishing time is divided by the distance of that race, the quotient is the pace the runner averaged during the race. Although pace is a relative measure, the measure of pace does not translate to compare times between races because of factors like different race courses, different altitudes, different weather conditions, and the farther the race distance the slower the pace a runner maintains. Another way to make a finishing time relative is to convert them into a percent of the average finishing time within the race in which it was run. Deaner (2006a) reported individual times as a percent of an elite standard. Translating times into percents of the world record made it easier to compare men's and women's times to each other. Reporting times as a percent of that event's world record represents a relative measure. In this study, the *relative* race measures used included Coefficient of Variation (CV) and Rates of Separation. See "Procedures for Calculation of Variation Variables" in Chapter Three for further explanation.

Coefficient of Variation. Coefficient of Variation is a statistic similar to a standard deviation; however, unlike a standard deviation, it is a relative measure. CV is the product of 100 and standard deviation of a data set divided by the mean of that data set (see Equation 1 below). CV represents the standard deviation as a percent of the mean. The greater the coefficient of variation, the greater the variation within the data set.

$$CV = 100 * (SD / M)$$

Equation 1. Coefficient of Variation (Norusis, 2010)

Interpercentile Range. An Interpercentile Range is the amount of time that elapses between two percentile finish times. A percentile is a rank for each point within a data set that describes where that point lies. If the data set, for example, is all the integers from one to 1,000, the number 100 would be the 10^{th} percentile because it is higher than 10%

of the numbers within the data set; 250 would be the 25th percentile. An Interpercentile Range is the time between two percentile finishers. Using the previous example, 150 would be the Interpercentile Range between the 10th and 25th percentiles in the data set of all the integers from one to 1,000.

Hypotheses

The hypotheses of this study are:

1. Women's races will show a greater variability (i.e., relative race variation) than that of men's races. That is, the finishers within women's races finish more spread apart from each other compared to the finishers within men's races.

2. Women's races will show less of an absolute race variation than men's races. That is, the differences between the Interpercentile Ranges will be greater for men's races than for women's races and therefore the current competition distances will be determined to be inappropriate. It is anticipated this analyses will suggest either men should run a shorter competition distance or women should run a longer competition distance compared to what is currently run.

3. The statistically appropriate distances for women's and men's race will be closer in distance than the current competition distances. This hypothesis emerged from the combination of the first and second hypothesis.

Limitations and Delimitations

One limitation of this study was that the corresponding championship races may not be equally competitive for men and women. It may be the case that the men's NCAA Division I championship race is more competitive than the women's Division I championship race or that the women's NCAA Division III championship race is more competitive than the men's Division III championship race. This is a limitation because it could be the case that competitive races tend to have runners finish closer together than less competitive races. Therefore, it is assumed that corresponding races from each division are equally competitive for men and for women.

Another limitation was that this study compares races of two different distances. It may be the case that longer races tend to have a greater variation relative to shorter races, but without data from other distances at the national championship collegiate level, it is difficult to know if that is or is not the case. Therefore, it is assumed that races of different distances spread apart at the same rate.

Delimitations correspond to the types of races considered. Only collegiate national championship races will be analyzed. Therefore, results cannot be assumed to translate to college races during the season or at a regional level. Only college races were analyzed; the results may not hold true for high school or elite level races. This study will only analyze cross country races, so the findings should not be applied to races on a track or those races on the road. These analyses will utilize competitive athletes, thus results cannot be applied to noncompetitive athletes. Thus, the scope of this study is limited to collegiate national championship races.

Significance of Study

No similar study has been conducted previously and if gender differences emerge on variations in finishing times, it may be worth exploring further to determine why it may be the case that there is a difference. Also, if there is a variation difference, it would suggest men's and women's races are different and justify why they compete over different distances. If there is not a difference in the analysis, then this finding will provide further justification as to why women and men should be competing over the same distance. At the very least, such a finding should encourage additional research to explore other possible gender differences that may justify this difference in race distance.

CHAPTER TWO: LITERATURE REVIEW

The sport of cross country is a competition run over a course with varied terrain. Based on my experiences as a runner and competitor, a course may include any type of surface, but grass and dirt are the most common competition surfaces. Golf courses are often used as cross country venues. Although each competition is a race of individuals, teams also compete against each other and team scores are based upon the individual placing of their runners. The runner who wins the race individually scores one point for the team, the runner who places second scores two points, the runner who places third scores three points, and so on. Usually, seven runners compete per team with the sum of the first five finishers from each team equaling the team score. The lowest team score wins a cross country meet. There is no limit to the number of teams that compete in a race. College national championships have approximately 30 teams involved in a competition.

Within the United States, four-year institutions compete within one of two governing bodies: the National Association of Intercollegiate Athletics (NAIA) or the National Collegiate Athletic Association (NCAA). The NAIA has almost 300 member institutions, which includes institutions within Canada as well as the United States. The NAIA views sport as part of the process of education (NAIA, 2011a). The NCAA is divided into three divisions: Division I (DI), Division II (DII), and Division III (DIII).

The NCAA views athletes as students first and uses the term "student-athlete" to describe their participants. DI institutions must sponsor at least 14 total sports, during the fall, winter, and spring, plus meet certain financial aid requirements. Generally speaking, this division is the most competitive of all college classifications; 335 institutions are classified as DI. DII institutions (n = 302) must sponsor at least 10 total sports and offer some financial aid, but less than DI institutions, and tend to be less competitive than DI institutions. DIII institutions (n = 447) have less rigorous standards for inclusion, do not offer financial aid for athletics, and most of them are private schools (NCAA, 2010). Hence, for the purpose of this study, *Level* will be used to classify the NAIA and three divisions of the NCAA.

The goal in cross country racing, as in any race, is to reach the finish before any of the other competitors; therefore, lower finishing places and times represent better performances. In the NCAA, women run 6 km across all divisions and men run 10 km (DI & DII) or 8 km in DIII. Typical finishing times for women over 6 km average 21 minutes, whereas men average 31 minutes for 10 km and 26 minutes for 8 km. The NAIA has women compete over 5 km and men over 8 km with typical times of 19 minutes and 26 minutes, respectively. Records for each race include every finisher’s place and time.

This literature review draws from research conducted and opinions on gender differences, previous analyses of races conducted on gender differences, as well as research within the field of sport psychology and sociocultural gender differences. The review of the literature from various subdisciplines suggest that women’s cross country races will have a greater variation in finishing times than the times within men’s races.

Several researchers suggest that women will likely outperform men in running events (Bam, Noakes, Juritz, & Dennis, 1997; Hoffman, 2008; Tatem, Guerra, Atkinson, & Hay, 2004). One survey determined that 66% of Americans believed the top women would eventually catch up to the top men in sport (Holden, 2004). Yet, many researchers have found the gender performance gap appears to have stabilized (Deaner, 2006a; Hoffman, 2010; Sparling, O'Donnell, & Snow, 1998) with the majority concluding that the gender performance gap stabilized sometime in the 1980s. It is likely that the remaining gender performance gap is mainly due to biological differences (Cheuvront, Carter, DeRuisseau, & Moffatt, 2005).

Ultra-endurance events have been thought to be more suited to females than to males (Bam et al., 1997; Hoffman, 2008) because females not only have greater fat stores than males, they also are more efficient at utilizing those fat stores as a fuel (Tarnopolsky, 2000). Females with a similar marathon performance to males have been documented to perform better at 90 km races than those comparative males (Speechly, Taylor, & Rogers, 1996), lending empirical evidence to this claim. This trend, however, has not been seen in world class ultra-marathoners. Specifically, female world records at distances beyond the marathon are actually further behind male world records than at the marathon distance and below (Coast, Blevins, & Wilson, 2004).

Deaner (2006a) illustrates these differences through archived data from high school, college, and elite level competitions when best performances across each of the three levels were compared to a corresponding elite standard. The top 40 elite level performances (i.e., 100 m, 200 m, 400 m, 800 m, 1,500 m, 5,000 m, 10,000 m, and marathon distances) taken from *Track and Field News*, collegiate performances (i.e., 100 m, 200 m, 400 m, 800 m, 1,500 m, 5,000 m, and 10,000 m distances) from national qualifier lists, and high school performances (i.e., 100 m, 200 m, 400 m, 800 m, 1,600 m, 3,200 m distances) from a book of high school track performances were all compared to each event's respective world record. These analyses showed that in 20 out of the 21 events, males as a whole were closer to the world record on a percent basis than females. Deaner (2006a) then analyzed the same data replacing the world record with a value identified as the 10-Fastest standard (i.e., the mean time of the 10 fastest marks achieved in 2003 of each event). The second analyses showed that in 18 of the 21 events, males performed significantly closer to the elite standard. These findings illustrate that more males perform at a higher level relative to an elite standard than females.

Deaner (2006b) also analyzed data from specific races in addition to performance lists. Twenty of the largest 5 km road races and 20 of the largest marathon road races in the United States in 2003 were used in his analysis. Forty places in each race for males and females were used in the analyses. To take into account participation differences, if twice as many men finished the race as women, then the 2nd, 4th, 6th, and so on until the 80th male finish times were used with the comparative number of female finish times. Similar to Deaner's (2006a) study, times were compared to the 10-Fastest standard. Significant differences emerged for 18 of the 20 5 km races and 18 of the 20 marathons, all in the direction of males performing closer to the 10-Fastest standard. The magnitude of these gender differences were estimated by comparing how many females performed at the relative same level as the 40th male in each race. If 20 females performed at relatively the same level as the 40th male then the bias ratio would be two; that is, twice as many males ran close to the 10-Fastest standard as females. The mean bias ratio for the 5 km races was 2.1 and 2.6 for the marathon distance. This finding suggests there were twice the number of men running competitive times as women in U.S. road races. These results suggest that males perform closer to the 10-Fastest standard than females.

Frick (2011) performed similar analyses as Deaner (2006a). Frick used the top 200 men's and women's performances of all time in four different track events (i.e., indoor 3,000 m, outdoor 3,000 m, 5,000 m, and 10,000 m) and nine different road race distances (i.e., 5,000 m, 8,000 m, 10,000 m, 15 km, 10 mile, 20 km, half marathon, 25 km, and marathon). The analyses computed the percent difference between the corresponding male and female times; the world records were compared to each other on a percent difference as were each second and third fastest time and so on to the 200th fastest time. Frick found the 200th best performance for women was always a greater percent behind the 200th best performance for men than the percent difference between the corresponding world records.

Frick also compared the variability within the men's and women's best marathon times each year from 1973 to 2009. He showed that in 2009, the women's variability in finishing time was closer to the men's variability than in any other year. Frick does not, however, report these data in terms of any statistical significance but speculates the women's times will continue to move closer together in the future. Frick found also that the age range for best performance was similar for both men and women, which suggest the more prestigious events have a smaller age range of elite performers. Frick claimed that economic incentives are driving a gender discrepancy in competitiveness. Incentives of major marathons used in Frick's analyses included prize money and appearance fees. If an athlete finishes a marathon in a high enough place, that athlete will be rewarded with prize money and the higher the place, the more the money. Similarly, race directors will give the top elite athletes appearance fees just to start the race. This practice tends to get quality fields of competition and appearance fees are based on a runner's previous results.

Many explanations exist as to why a difference exists between males and females in distance running performance. Frick (2011) provides three explanations. First, the evolutionary psychology perspective claims that gender differences exist because of selective pressures that have made the genders psychologically different. Perhaps, it was the case that through much of human history, it was advantageous for males to be more wired for direct competition than females, and as a direct result, males are more likely to be competitive today. Second, the sociocultural explanation proposes that gender differences emerge because of a discrepancy in how males and females are raised and treated. An example of this notion would be that boys may be encouraged more to participate in sport than girls and because of this difference a higher percent of males compete in sports and they may be relatively more competitive than girls. Third, the economic explanation claims that differing incentives for males and females result in differing finish time distributions for male and female participants. If males had more of an opportunity to make money in running, then they would have a greater economic incentive than females to compete and thus would be expected to compete at a higher rate and more competitively.

Several studies have found results contrary to Frick (2011). Deaner (2006a), for example, examined the change over time in this gender gap to determine whether any possible sociocultural factors could explain this difference, and/or if the gender gap is narrowing. Deaner found that performances by females, relative to that of males, did not improve between the mid-1980s and 2004, with the exception of sprinting events in high school. The number of competitive female distance running performances appears to have stabilized during the middle of the 1980s. Sparling and colleagues (1998) found that the depth or number of competitive performances in women's marathoners increased from 1980 to 1984, but has not increased since, suggesting that the effects of social changes happening before and during that time such as Title IX, which became federal law in 1972, may have increased the depth of field (i.e., quality of the top runners). The 100 mile women's ultra-marathon elite performances from as early as 1977 through the 1980s were getting closer to those of the men's elite performances; however, women's performances appear to have reached a plateau by the 1990s, and when compared to men, women showed greater percentage spreads than men within the top five finishing times (Hoffman, 2010).

Given that Frick's (2011) research analyzed the most recent race results, it is tempting to view his analyses as relevant because he had the most current data to analyze. His findings are limited to gender variation difference using only marathons as evidence and not a larger collection of races. Deaner (2006a, 2006b) evaluated track races and shorter road races.

Research on Gender Difference in Sport Psychology

The field of sport psychology has examined gender differences in a numbers of contexts (for reviews see, Gill & Williams, 2008). Many of these differences possibly manifest themselves in a way that would spread out a women's field of distance runners faster than a men's field. Competitiveness, goal orientation, win orientation, risk taking, efforts within competition, group dynamics, and motivation are just a few psychological variables on which gender differences have been reported.

Gender Differences in Competition

Gender differences in certain types of competitiveness have been well documented, namely that males seek out competition and want to compete more than females (Cashdan, 1998; Gill, 1986; 1994; Niederle & Vesterlund, 2007; Stevens et al., 2002). Cashdan examined whether one sex was more competitive than the other in overall competitiveness, as well as in varying subtypes of competitiveness. Cashdan defined being competitive as any instance of competition, therefore the more times an individual competed against another person, the more competitive that individual. There were two studies in her paper, both of which used diaries from participants. The main areas of competition examined were school, work, sport, being attractive, attracting attention, and status. In both studies, men competed more in sports, and women competed more in looking attractive. Females were shown to compete more for the attention of the opposite sex in the first study. The amount of overall competition was statistically the same for each gender. Cashdan suggests that sports are more important to men and looking attractive is more important to women, but the two genders are equally competitive overall.

In 2007, Niederle and Vesterlund conducted a study comparing males and females competing in solving mathematical equations. The study began by having all the participants solving equations in what is known as a noncompetitive piece rate tasks in which participants receive 50 cents for every correct answer. Then, participants were put in groups and performed a competitive tournament incentive scheme task in which the first participant to solve the equation correctly received two dollars but only the first participant to answer correctly received money. Finally, the participants were given the choice to play the noncompetitive task or the competitive task and the males chose the competitive task twice as often as the females. Within the experiment, males and females were equal in performance and the researchers suggested that males may tend to compete too often and females may tend to shy away from competition. Within Niederle and Vesterlund's study, being competitive is defined as wanting to compete, similar to Cashdan (1998).

Gill (1986) investigated gender differences in competition using students from competitive and noncompetitive physical education classes. Students were given a questionnaire designed to measure achievement motivation (i.e., work, mastery, and competitiveness). Overall, males scored significantly higher than females on competitiveness. Gill defined competitiveness as "the desire to succeed in competitive, interpersonal situations," which is closely related to sports, lending support for Cashdan's (1998) study.

Gender Differences in Goal Orientation

Gender differences are not only found in competitiveness but also in how males and females view their own success (Gill & Deeter, 1988). Gill and Deeter define goal orientation as a personal measure of success. Individuals who are aligned with a goal orientation measure their own success against their previous accomplishments and not by whether they have beaten another person in a competition.

Females have been shown to score higher on goal orientation (Gill, 1986; 1994; Stevens et al., 2002). Gill (1986) found in a sample of physical education students that females scored significantly higher on goal orientation than males. The same result has been reported in additional publications (Gill, 1994; Stevens et al., 2002). If females tend to adopt a goal orientation in sport, it is plausible that they may let their competitors run away from them during a race because they are more concerned with their own performance.

Individuals who are guided by a win orientation measure their successes and failures by whether they have beaten someone else. Gill's (1986) study with physical education students revealed gender differences on the win orientation that were greater than any other variable examined; males scored higher than females on win orientation. If males tend to measure their success by how they perform in relation to others, it is anticipated that males would try to run with the leaders of a race for longer than females because males' perception of their own success depends on beating as many competitors as possible.

Gender Differences in Risk Taking

Gender differences in risk taking behavior have been well documented (Brynes, Miller, & Schafer, 1999). Brynes and colleagues reviewed 150 studies conducted on risk taking behavior. Their meta-analysis separated risk taking into 16 different categories and it was found that males exhibited more risk taking behavior in 14 of those categories. Physical skill was the category that showed the greatest mean difference between males and females. Given that sport is physically demanding, it is plausible that males tend to take more risks than females during a sporting competition. Based on the finding that females tend to be less willing to take risks, they may be less likely to try and run with a woman who is a favorite or a woman who passes them during a race. This race mentality may contribute to the women’s races being more spread out than men’s races.

Gender Differences in Effort Level and Group Identification

Individual effort has been shown to vary between men and women. Gill and Prowse (2010) conducted a study in which participants had to perform a computer sliding task where the score on the task was a reflection of their effort. Participants received monetary compensation after successful trials. Effort levels after successful and failed trials were noted and women showed a greater reduction in effort following a failed trial than men. Applying this finding to distance running might suggest that more women would reduce their effort during a race at the onset of any perceived failures within the race. These findings, however, are based on a computer task, which may or may not generalize to tasks such as sport effort.

Gender differences for group effort and affiliation have been found also within the field of behavioral economics. Specifically, Van Vugt and colleagues (2007) assigned participants to one of two groups: competitive or noncompetitive. These participants were in groups of six and presented with a small sum of money. Then, group members were told that if they donate their money to the group and enough of their group members did the same, the whole group would get a larger sum of money once it was divided evenly. The internal debate for the participants was that if they kept their money and their group donates enough money to the pot, they would keep both their original earnings plus a share of the group's winnings, making it so they have more total money than anyone else. The competitive group was told their results would be compared to that of other universities and the noncompetitive group was to simply play the game. It was found that within the competitive condition, men contributed more to the group than women, and men contributed more to the group when in the competitive condition than when in the noncompetitive condition. Women gave roughly the same amount in both conditions. This finding was replicated in two additional studies within the article. Given that a cross country runner is running as a member of a team competing against other teams, applying the findings of this study suggest males may put forth more total effort than females when competing and potentially contribute to less of a spread in times for a race.

Suver (2009), who is concerned with the differences between male and female distance runners, used an online survey to investigate variables of effort level, group identification, and importance of relationships. Results from this online survey suggested that although relationships were more important to women, those relationships did not affect the effort of women in a race. In contrast, social cohesion predicted the effort for men during a race. More importantly, men who were distance runners also showed more satisfaction with their own performance if they had a greater identification with the group. The sport of cross country is more team affiliated than any other type of distance running and given the team affiliation, it is plausible they give more to the group effort than women, further exacerbating the gender gap hypothesis in variation of race times. If women tend to give the same effort regardless of these external factors, it reinforces the notion that females score higher in goal orientation and males score higher in win orientation. These findings are congruent with earlier findings from behavioral economics that men donate more of their money to a group's success if that group is competing against another group (Van Vugt et al., 2007).

Gender Differences in Motivation

In line with gender differences identified thus far on competitiveness and goal orientation, males and females are motivated to participate by different factors (e.g., competition, fitness, or teamwork). In a study that surveyed 1,472 adolescents in Australia, New Zealand, and the United States, males reported that competition and energy release were reasons to participate in sport more than females. Conversely, females reported that fitness and teamwork were more important reasons for sport participation than males (Weinberg et al., 2000). This study further validates the claim that males tend to be more competitive than females within sport; however, results may differ for other competitive collegiate athletes.

Weinberg and Ragan (1979) assessed 100 college aged males and females on differences in motivation. Participants were judged using a motor task that required them to follow a target with a stylus. Participants were assigned randomly to either a head-to-head competition (i.e., participants in this group were told they were matched against another participant) or competition against a standard of excellence (i.e., participants in this group were told how they performed within a percentile ranking). Participants received results in terms of either success or failure. This study also contained a control group that performed the task alone with no external reference. Participants then were asked how enjoyable the task was on a 7-point scale and were asked to volunteer for a future experiment. Males showed more intrinsic motivation in the competitive group than in the noncompetitive group by rating the enjoyment of the task higher, while females showed no differences. Males also volunteered more after the experiment had finished, which was interpreted by the researchers as males having a higher level of intrinsic motivation for competition. Although the study is over 30 years old and the effects of Title IX and other such social changes could impact the results of this study were it done today, it is unlikely that such social changes would influence the enjoyment of a mundane task such as following a target with a stylus.

Gender Differences in Leadership

Leadership is important when it comes to group competition such as cross country races. Van Vugt and Spisak (2008) found that gender was an important variable within perceptions of leadership. Specifically, Van Vugt and Spisak assigned participants to one of three different competition groups (i.e., intragroup; intergroup; a combined group) and a control group that involved no competition. Participants were asked to vote for a candidate to lead their group and found that participants were more likely to vote for a female leader within intragroup competition and a male leader within intergroup competition. This study found that intragroup competition participants gave more to the group if the leader was a female; conversely, participants gave more to the group within an intergroup competition if the leader was a male. These findings suggest that males may be more likely to be leaders in competitive sport because sport is most often an intergroup competition. Males may be perceived also as better leaders in sporting competition than females; although females may be perceived to be better team captains.

Cross country is the closest one gets to intergroup competition, as opposed to individual competition, within distance running because the majority of runners score (i.e., five out of seven) on each team. Therefore, each runner's performance contributes an important part of the team's success. If the results of Van Vugt and Spisak (2008) generalize to that of competitive sport, it is anticipated that males will put forth more effort than females because their leader is a male. Also, given the results from Van Vugt and Spisak's study, it is possible that females would perform at a relatively higher level than males within an intersquad competition or a group time trial. These findings are consistent with the fact that females reported teamwork as more important than males (Weinberg et al., 2000).

Gender Differences in Competitive Stress

In a study of Australian basketball players (Madden & Kirkby, 1995), men were shown to experience more stress related to their own team's performance than women. Researchers attributed this result to either men having a greater investment with the outcome of the game than women or women believing they had less influence on the game's outcome. While men may show more stress from the outcome of the event, women report more coach-related stressors (Anshel, Sutarso, & Jubenville, 2009).

The totality of the research reviewed within this chapter may suggest that males, through years of selective pressures, may be more psychologically wired for direct competition than females, especially during intergroup competition. This notion is consistent with Van Vugt et al.'s (2007) notion of the male warrior hypothesis: that males have had more reproductive success in the past when they are successful in competitions that have a clear winner and loser; whereas, females would not have enhanced their reproductive odds in the same sort of competitions.

Sociocultural Influences on Gender

Sociocultural variables such as participation rates have been proposed also as to why a gender gap exists in competition (Frick, 2011). Differences in participation rates between males and females, as well as how males and females tend to be raised, may be partly to blame for this gender gap. Specifically, males show a higher participation in distance running than females in high school. Deaner (2006a) reported participation numbers from the National Federation of State High School Association (NFSHSA) that indicated males have slightly more schools that sponsor track and field with 21% more participants than females at the high school level. These numbers suggest that in high school, not only are there more male teams than female teams; male teams have more participants on their rosters.

The participation gap is reversed in DI athletics where there are nine percent more female track and field teams with only two percent more female athletes overall (as cited in Deaner, 2006a). This reversal is most likely the result of more scholarship money available to female track athletes than male track athletes and university strategies for Title IX compliance. It is possible that the greater participation numbers for males during high school contributes to some of the differences in the finish time distribution (Deaner, 2006a). Theoretically, the higher the participation, the more competitive a sport, and the more likely it is that participants will finish closer together. Deaner, however, developed the biased ratio that explains the number of males running relatively fast to the number of females running fast. Based on his formula, Deaner deduced there are two to four times as many males who run fast as compared to females. This statistic is based on how many males and females run within an accepted percent of his 10-Fastest standard. It is unlikely the differences found in high school participation numbers alone can explain the gender gap that has emerged in finish time distribution at the collegiate and open level.

One particular finding to emerge about natural talent may show that males are more likely to compete in sport (Li, Lee, & Soloman, 2006). Specifically, Li and colleagues reported that college-aged men believe that natural talent is a more important variable as it relates to success than college aged women and this was found across a spectrum of different sports. Natural talent is thought to be more important at an elite level of competition than at a recreational level by both males and females. This finding makes sense because it stands to reason that when a high number of people compete in an activity, the higher the level of success, the more natural talent is required to reach that level.

To attribute all of the variation between genders to only social or biological factors would be short-sighted and naïve (Eccles & Harold, 1991). This debate is not unlike a nature versus nurture debate, in that, it is not a matter of determining which factor is responsible for these differences, rather how much each factor contributes to the differences that have emerged.

To add to the research conducted thus far, collegiate cross country races were analyzed on the differences in finish time distribution by gender. There was a need for such analysis to be conducted because the college distance runner population has not been examined in this way. Most of the analysis has been done from performance lists or a collection of the best marks for a given event over a defined timeframe rather than from individual races. Another reason this analysis was conducted was to examine rate of separation beyond just the first several times and to assess whether differences were found near the center of a race as well as at the back of the race.

CHAPTER THREE: METHODS

Data Source

Data were retrieved from archival public domains for collegiate championship races (NAIA, 2011b; NCAA, 2011). NCAA cross country championship data from all three divisions (i.e., DI, DII, and DIII) starting in 1999 through 2011 were used in analyses. For NAIA cross country championship, data from 2005 to 2011 were retrieved and analyzed. The retrieval process resulted in 13 men's and women's races from each of the three divisions within the NCAA, as well as seven men's and women's races from the NAIA. Table 1 contains a breakdown of the number of participants from 46 men's and women's races. In total, there were 10,788 participants in men's races and 10,884 participants in women's races (21,672 participants total).

Each respective national championship had similar numbers of participants within the years analyzed (see Table 1). The race results from all of the NCAA championship races were downloaded from the NCAA's website (NCAA, 2011) and the NAIA results were downloaded from the NAIA's website (NAIA, 2011b). The pertinent information for this study included the race time of each finisher, the finisher's place within the race, gender, competition levels, and year of the competition. All relevant data were entered into SPSS 19 for statistical analyses.

Table 1

Number of Male and Female Participants for NCAA by Division and NAIA

	NCAA							
	DI		DII		DIII		NAIA	
Year	Males	Females	Males	Females	Males	Females	Males	Females
1999	253	254	131	132	212	213	--	--
2000	255	255	184	180	215	211	--	--
2001	244	249	179	183	211	213	--	--
2002	251	254	186	184	213	215	--	--
2003	249	252	176	189	207	206	--	--
2004	242	248	183	188	214	211	--	--
2005	253	253	172	180	211	213	262	259
2006	250	253	187	187	279	279	255	268
2007	250	253	187	189	280	280	258	268
2008	252	252	184	190	278	279	331	327
2009	250	254	182	184	276	279	323	330
2010	246	253	182	187	279	279	326	311
2011	252	254	187	186	279	277	312	323
Totals	3,247	3,284	2,320	2,359	3,154	3,155	2,067	2,086

Procedures for Calculation of Variation Variables

Coefficient of Variation

Coefficient of Variation (CV) was used within this study as a marker of relative variation. CV is the standard deviation divided by the mean multiplied by 100 (see Equation 2; Norusis, 2010). A higher CV for a race indicates a higher variability within that specific race. Each individual race will have one CV.

$$CV_{Level\ by\ Year\ by\ Gender} = 100 * (SD_{Level\ by\ Year\ by\ Gender} / M_{Level\ by\ Year\ by\ Gender})$$

Equation 2. Coefficient of Variation (Norusis, 2010).

Interpercentile Ranges

In an attempt to quantify the absolute variation within a race Interpercentile Ranges (IR), or the time difference between percentile ranks, was utilized for comparison between races; that is, comparing differences in finishing times between selected percentile ranks may provide a good metric for the spread of finishing times. An IR is the difference in times between two percentile finish times.

The difference in time between three IR (i.e., 25^{th} - 75^{th}; 10^{th} - 90^{th}; 5^{th} - 95^{th}) were computed. To illustrate, utilizing a race with 200 finishers, the 10^{th} place finisher represents the 5^{th} percentile finishing time and the 190^{th} place finisher represents the 95^{th} percentile finishing time. The difference in finishing time between the 10^{th} place finisher and 190^{th} place finisher would be in the $IR_{5th\ -\ 95th}$ and this time represents the amount of time that elapses from when the 10^{th} place finisher crosses the line until the 190^{th} place finisher crosses the line. The 20th place finisher represents the 10th percentile finishing time and the 180th place finisher the 90th percentile finishing time.

These three IRs may provide a useful assessment of the finishing times spread for runners. These percentile differences will help determine if the runners who finish in the middle of the pack are closer together than the finishers in the front or back of the race, as expected in a normal distribution. These percentile differences provide another metric of the time spread without extreme cases (i.e., the first few finishers and last few finishers) affecting the results.

Each IR was chosen for specific reasons. The 25th - 75th percentile range was chosen because it represents the middle half of race finishers. The 10th - 90th percentile range was chosen because the data represent approximately two standard deviations from the mean. The 5th - 95th percentile range was computed to include most of the race finishers while eliminating potential outliers.

Rates of Separation

In order to have a second marker of relative variation, rates of separation were computed. The rate of separation reveals how quickly two runners separate from each other. The unit for this measure is seconds per kilometer or how many seconds separate two runners for each kilometer run. The IRs were utilized to compute the rates of separation and the rate of separation for the 25th -75th percentile finishers were computed to determine the 25th-75th rate, the 10th-90th, and 5th-95th rates were computed as well. Equation 3 illustrates how the rate of separation (RS) was computed.

$$Rate\_of\_Separation = {(Upper\_Percentile - Lower\_Percentile)} / {Race\_Dist.}$$

Equation 3. Rate of Separation

Statistical Analysis

In order to test the first hypothesis that women will show more relative variation within finishing times of their respective races, the CV as well as the RSs were needed for this analysis. The first test compared the CV from men's races to that of women's races using an independent *t*-test. The independent *t*-test was determined instead of a dependant *t*-test because of the likelihood of finding a statistically significant result. It will be less likely for significance to be reached using an independent *t*-test so any significance found will likely be more compelling than using a dependent *t*-test. Once described below, a total of 25 statistical tests were conducted to test the three hypotheses. Because of this number of statistical tests carried out, .05 was divided by 25 to determine an alpha level of .002 for each of the 25 tests.

The second analysis used to test whether women will show greater relative variation than men on finishing time variation utilized rates of separation. Three independent *t*-tests were performed for each RS (i.e., 25^{th} - 75^{th}, 10^{th} - 90^{th}, 5^{th}-95^{th}) by level (i.e., three NCAA divisions; one NAIA). Independent *t*-tests were chosen for the same reasons as stated above. Each level was tested separately because the same distances are not all run at each level; DI women run 60 % of the DI men, whereas DIII women run 75 % of the DIII men and this may affect the results.

In order to test the second hypothesis, men will show greater absolute variation in finishing times than women, the IRs were used. Three independent *t*-tests were performed for IRs (i.e., 25^{th} - 75^{th} range, 10^{th} - 90^{th} range, and 5^{th} - 95^{th} range) by level.

The third hypothesis states that in order for men and women to show equal absolute variations, either the men's race distance needs to shortened or the women's race distance needs to lengthen. Hypothesis three represents a combination of the first two hypotheses. Given that the analysis would not be complete without attempting to quantify the magnitude of difference between races for men and women, a formula based on the RS was devised to see what distances would be statistically appropriate to run for men and for women.

The RSs were entered into the statistically appropriate distance formula (see Equation 4). To determine the statistically appropriate distance for females to run, each race by year and level had three separate statistically appropriate distances for the women, one based on the corresponding $RS_{5th\ -\ 95th}$; one on the $RS_{10th\ -\ 90th}$; and one on the $RS_{25th\ -\ 75th}$. In order to determine statistically appropriate distances for women, the formula multiplies the RS of the men's race by 10 and then sets the product equal to the corresponding RS from the women's race in the same year and level multiplied by *x*. This calculation will result in a statistically appropriate distance for the women.

$$\left(RS_{males\_by\_level} \times 10km\right) = \left(RS_{females\_by\_Level} \times Xkm\right)$$

Equation 4. Predictive distance for equal distribution of times.

The above equation illustrates how statistically appropriate competition distances were calculated, assuming that the goal of the competition distance is to have a relatively equal variation for men and women. The equation uses the men's DI and DII distance of 10 km to anchor the data. This decision may be viewed by some as sexist; however, 10 km was chosen as the anchor for three specific reasons: (a) 10 km historically has been the championship distance before the advent of women competing in college cross country; (b) 10 km results are transferable easily to a percent or proportion; and (c) finally, simpler math. The statistically appropriate distance formula can be formulated as a function on the Cartesian coordinate system (see Equation 5), where 'y' equals the men's distance, 'x' equals the women's distance, and (RS of men divided by the corresponding RS of the women) equals the slope of the line.

$$y = x(RS_{male} / RS_{female})$$

Equation 5. Predictive distance for equal distribution of times as a function.

CHAPTER FOUR: RESULTS

Descriptive Statistics

Table 2 contains the average finishing times (in seconds) and standard deviations for each race. The average times fluctuate a bit from year-to-year; however, this fluctuation may be attributed to course difficulty and/or weather conditions, with a noted exception in 1999. At that time, women within DI ran 5 km at the national championships; since then, women have run 6 km.

Coefficient of Variation

The CV from each championship race is contained in Table 3. These values were used to test the first hypothesis of this study. The first hypothesis predicted that women's championship races would have a greater relative variability than men's championship races. An independent *t*-test was employed to test this hypothesis. The test revealed a significant difference in the predicted direction, $t = -4.17$, $df = 90$, $p < .001$. The difference between the males and females on CV was significant and in the direction anticipated: that is, women's races resulted in more variability than men's. This finding lends support for hypothesis one. By comparing men's and women's races within the same level and year, each race for woman had a larger CV than the corresponding men's race with only one exception (i.e., the 2000 DII national championships).

Table 2

Means and Standard Deviations for Finishing Times by Year, Gender and, Level

	DI		DII		DIII		NAIA	
Year	*M (secs)*	*SD*	*M (secs)*	*SD*	*M (secs)*	*SD*	*M (secs)*	*SD*
1999								
Males	1,949.88	69.12	1,955.91	81.09	1,518.83	44.51	--	--
Females	1,093.35	44.76	1,376.30	68.70	1,106.73	64.29	--	--
2000								
Males	1,922.37	54.03	2,083.48	148.20	1,594.14	50.89	--	--
Females	1,339.29	54.76	1,458.33	91.31	1,165.95	40.85	--	--
2001								
Males	1,875.27	62.31	2,083.11	121.96	1,555.21	55.58	--	--
Females	1,343.57	54.41	1,444.84	90.08	1,121.85	44.83	--	--
2002								
Males	1,890.19	62.02	2,022.38	90.27	1,596.40	51.35	--	--
Females	1,291.58	62.31	1,443.85	83.89	1,408.02	58.99	--	--
2003								
Males	1,868.76	54.03	2,032.62	97.07	1,611.42	60.40	--	--
Females	1,288.44	55.48	1,432.42	83.79	1,434.56	63.46	--	--

Table 2 (cont.)
Means and Standard Deviations for Finishing Times by Year, Gender, and Level

	DI		DII		DIII		NAIA	
Year	*M (secs)*	*SD*	*M (secs)*	*SD*	*M (secs)*	*SD*	*M (secs)*	*SD*
2004								
Males	1,971.68	62.92	2,082.96	93.96	1,570.92	51.92	--	--
Females	1,331.12	53.24	1,454.21	78.41	1,406.19	61.52	--	--
2005								
Males	1,876.63	54.65	2,075.38	125.88	1,638.61	52.06	1,596.72	65.44
Females	1,286.32	51.56	1,442.07	95.12	1,443.64	60.77	1,176.71	55.60
2006								
Males	1,973.35	63.33	1,911.87	96.18	1,740.96	70.84	1,614.47	68.50
Females	1,345.50	54.32	1,351.80	89.25	1,520.30	71.92	1,195.42	66.04
2007								
Males	1,887.20	60.33	1,980.16	101.59	1,565.40	44.68	1,595.25	63.04
Females	1,308.85	48.83	1,377.38	76.78	1,393.17	50.01	1,175.23	63.76

Table 2 (cont.)

Means and Standard Deviations for Finishing Times by Year, Gender, and Level

	DI		DII		DIII		NAIA	
Year	*M (secs)*	*SD*	*M (secs)*	*SD*	*M (secs)*	*SD*	*M (secs)*	*SD*
2008								
Males	1,869.04	52.82	1,955.91	81.09	1,552.68	55.25	1,616.10	94.65
Females	1,287.34	47.59	1,376.30	68.70	1,370.36	54.65	1,177.69	76.10
2009								
Males	1,878.18	65.94	2,083.48	148.20	1,626.25	50.42	1,639.90	89.06
Females	1,294.29	52.20	1,458.33	91.31	1,442.04	61.11	1,232.50	80.08
2010								
Males	1,887.91	61.44	2,083.11	121.96	1,547.88	45.70	1,641.65	87.54
Females	1,298.36	47.43	1,444.84	90.08	1,364.30	47.46	1,208.67	87.59
2011								
Males	1,862.73	51.47	2,022.38	90.27	1,534.32	41.61	1,577.39	69.16
Females	1,276.09	46.87	1,443.85	83.89	1,359.24	51.22	1,195.23	64.19

Table 3

Coefficient of Variation for Male and Female Races by NCAA Division and NAIA

	NCAA							
	DI		DII		DIII		NAIA	
Year	Males	Females	Males	Females	Males	Females	Males	Females
1999	3.55	4.09	4.15	4.99	2.93	5.81	--	--
2000	2.81	4.09	7.11	6.26	3.19	3.50	--	--
2001	3.32	4.05	5.85	6.23	3.57	4.00	--	--
2002	3.28	4.82	4.46	5.81	3.22	4.19	--	--
2003	2.89	3.51	4.78	5.85	3.75	4.42	--	--
2004	3.19	4.00	4.51	5.39	3.31	4.37	--	--
2005	2.91	4.01	6.07	6.60	3.18	4.21	4.10	4.73
2006	3.21	4.04	5.03	6.60	4.07	4.73	4.24	5.52
2007	3.20	3.73	5.13	5.57	2.85	3.59	3.95	5.43
2008	2.83	3.69	3.96	5.24	3.56	3.99	5.86	6.46
2009	3.51	4.03	4.49	5.52	3.10	4.24	5.43	6.50
2010	3.25	3.65	4.46	5.50	2.95	3.48	5.33	7.25
2011	2.76	3.67	4.39	5.93	2.71	3.77	4.38	5.37

Interpercentile Ranges

IRs from each race were computed and used as a metric of *absolute* variability to determine whether the current differences in competition distance resulted in a similar absolute finish time variability. The differences in time between the 25^{th} - 75^{th} percentile finishers, 10^{th} - 90^{th} percentile finishers, and 5^{th} - 95^{th} percentile finishers were recorded for each race in Table 4. These values were utilized to test the second hypothesis that stated women's races show less *absolute* variability in finishing times than men's races. Tables 4 and 5 contain descriptive statistics across levels for all of the IR differences used within these analyses.

Independent *t*-tests were conducted by level (i.e., four) for each of the three IRs to test hypothesis two. The results of these tests are reported in Table 6. Significant differences emerged for NCAA DI and DII. Specifically, significant differences were found for males and females at the DI level for $IR_{10th – 90th}$ and $IR_{5th – 95th}$, and for the $IR_{10th – 90th}$ at the DII level in the direction of women finishing closer together than men. These differences indicate that the finishers of the women's races for DI and DII finish closer together than the corresponding finishers of the men's races. Three of the six results from DI and DII illustrate women's races tend to be less variable in terms of absolute finishing time than men's. This finding partially confirms the second hypothesis. For DIII and NAIA, no *t*-tests reached significance, indicating that women and men are not significantly different in terms of absolute variation.

Table 4

Interpercentile Range Differences (Sec) for NCAA by Year, Gender, and Level

	DI			DII			DIII		
Year	*5 - 95%*	*10 - 90%*	*25 -75%*	*5 - 95%*	*10 - 90%*	*25 -75%*	*5 - 95%*	*10 - 90%*	*25 -75%*
1999									
Males	230.89	172.42	95.80	257.44	236.46	113.60	145.83	111.80	55.40
Females	155.34	110.42	51.27	233.70	188.69	86.25	140.27	107.90	56.85
2000									
Males	167.84	137.88	64.25	441.86	290.34	163.25	145.83	111.80	55.40
Females	185.42	136.68	68.38	290.96	245.82	124.30	140.27	107.90	56.85
2001									
Males	201.50	158.50	82.75	310.90	237.80	118.70	172.80	139.80	68.00
Females	176.50	139.00	68.00	261.48	205.84	107.70	155.30	124.60	53.00
2002									
Males	210.76	153.06	72.80	300.83	221.86	102.05	163.18	120.98	66.05
Females	169.03	128.75	63.05	269.15	189.70	85.77	192.91	144.18	77.90
2003									
Males	186.80	133.30	64.05	317.36	252.72	129.48	195.52	144.12	71.80
Females	153.43	112.81	55.48	284.95	207.50	97.80	207.96	164.28	68.97

Table 4 (cont.)

Interpercentile Range Differences (Sec) for NCAA by Year, Gender, and Level

	DI			DII			DIII		
Year	*5 - 95%*	*10 - 90%*	*25 -75%*	*5 - 95%*	*10 - 90%*	*25 -75%*	*5 - 95%*	*10 - 90%*	*25 -75%*
2004									
Males	213.35	159.33	77.13	311.58	217.50	114.10	167.20	126.35	69.30
Females	173.79	139.98	76.40	279.62	191.81	109.73	191.34	145.08	76.80
2005									
Males	177.99	130.84	70.25	358.73	291.81	148.30	168.04	130.94	61.20
Females	181.24	133.38	68.05	300.58	224.07	123.53	186.43	142.82	80.70
2006									
Males	214.00	162.82	85.20	303.12	213.10	117.90	225.00	172.00	89.00
Females	177.26	143.88	68.85	268.24	197.30	104.60	243.00	192.00	98.00
2007									
Males	188.52	139.24	63.63	332.83	248.66	128.65	150.90	117.00	48.75
Females	168.61	127.54	61.20	255.48	199.38	108.28	173.95	128.80	59.00

Table 4 (cont.)

Interpercentile Range Differences (Sec) for NCAA by Year, Gender, and Level

	DI			DII			DIII		
Year	*5 - 95%*	*10 - 90%*	*25 -75%*	*5 - 95%*	*10 - 90%*	*25 -75%*	*5 - 95%*	*10 - 90%*	*25 -75%*
2008									
Males	172.88	141.04	64.25	252.75	202.00	97.00	125.13	100.31	55.33
Females	154.29	118.63	57.18	242.50	188.70	90.25	172.40	144.40	73.10
2009									
Males	210.89	158.96	72.22	318.54	230.40	113.58	168.30	136.64	67.73
Females	170.33	121.90	56.88	254.00	186.95	92.58	186.90	159.70	81.40
2010									
Males	181.06	148.67	79.83	270.43	218.41	129.50	159.90	117.60	56.10
Females	158.80	125.13	64.85	255.68	199.26	103.70	155.50	125.20	58.50
2011									
Males	169.74	136.52	68.55	271.20	224.16	121.00	135.32	107.82	54.61
Females	159.00	119.55	62.63	278.28	218.85	104.95	170.23	128.25	63.41

Table 5

Interpercentile Range Differences (Sec) for NAIA by Year and Gender

Year	*5 - 95%*	*10 - 90%*	*25 -75%*
2005			
Males	218.14	168.55	84.03
Females	190.78	147.73	72.27
2006			
Males	243.03	174.90	85.55
Females	198.99	149.47	70.70
2007			
Males	187.78	140.25	65.48
Females	176.10	152.77	74.55
2008			
Males	302.46	207.76	97.10
Females	239.24	175.00	79.20
2009			
Males	256.80	193.00	90.00
Females	268.50	199.90	86.00
2010			
Males	285.80	200.80	101.00
Females	277.00	211.00	92.00
2011			
Males	245.75	168.40	80.00
Females	218.40	173.60	70.00

Table 6

Means and Independent t-tests for Interpercentile Range Differences (Sec) by Gender and Level

	5 - 95%					*10 - 90%*					*25 -75%*				
Level	Males	Females	*t*	*df*	*p*	Males	Females	*t*	*df*	*p*	Males	Females	*t*	*df*	*p*
DI	194.32	167.93	4.13	24	< .001	148.66	127.51	4.51	24	<.001	73.90	63.25	3.20	24	.004
DII	311.35	267.28	2.98	24	.007	237.32	203.37	3.75	24	.001	122.85	103.03	3.29	24	.003
DIII	164.70	178.12	1.27	24	.216	127.68	139.05	1.34	24	.193	63.34	69.11	1.21	24	.239
NAIA	248.54	224.14	1.18	12	.263	179.09	172.78	0.49	12	.634	86.17	77.82	1.53	12	.152

Rates of Separation

The RSs for each IRs (i.e., 25th - 75th, 10th - 90th, and 5th - 95th) by race are presented in Tables 7 and 8. An independent *t*-test was conducted on the corresponding RSs (i.e., three) for each level (i.e., four) to determine whether men and women should compete over the same distance, provided that the goal of the race distance is to separate men's finishers equally to that of women's finishers. The results of these tests are reported in Table 9. The findings from all 12 Independent *t*-tests showed that women tend to separate from each other in cross country championship races at a higher rate than men at the corresponding levels.

These findings lend further support to the first hypothesis that women compete with a higher *relative* variability than men (i.e., women's races show a greater CV and RSs than men's races). It is suggested further, if the goal of setting the competition distances is to have men's and women's races show equal variation, then women should compete over the shorter distance.

Table 7

Rates of Separation (Sec/km) for NCAA by Year, Gender, and Level

	DI			DII			DIII		
Year	*5 - 95%*	*10 - 90%*	*25 -75%*	*5 - 95%*	*10 - 90%*	*25 -75%*	*5 - 95%*	*10 - 90%*	*25 -75%*
1999									
Males	23.09	17.24	9.58	25.74	23.65	11.36	18.23	13.98	6.93
Females	31.07	22.08	10.26	38.95	31.45	14.38	28.05	21.58	11.37
2000									
Males	16.78	13.79	6.43	44.19	29.03	16.33	20.50	16.81	7.53
Females	30.90	22.78	11.40	48.49	40.97	20.72	27.87	20.08	10.16
2001									
Males	20.15	15.85	8.28	31.09	23.78	11.87	21.60	17.48	8.50
Females	29.42	23.17	11.33	43.58	34.31	17.95	31.06	24.92	10.60
2002									
Males	21.08	15.31	7.28	30.08	22.19	10.21	20.40	15.12	8.26
Females	28.17	21.46	10.51	44.86	31.62	14.30	32.15	24.03	12.98
2003									
Males	18.68	13.33	6.41	31.74	25.27	12.95	24.44	18.02	8.97
Females	25.57	18.80	9.25	47.49	34.58	16.30	34.66	27.38	11.50

Table 7 (cont.)

Rates of Separation (Sec/km) for NCAA by Year, Gender, and Level

	DI			DII			DIII		
Year	*5 - 95%*	*10 - 90%*	*25 -75%*	*5 - 95%*	*10 - 90%*	*25 -75%*	*5 - 95%*	*10 - 90%*	*25 -75%*
2004									
Males	21.34	15.93	7.71	31.16	21.75	11.41	20.90	15.79	8.66
Females	28.96	23.33	12.73	46.60	31.97	18.29	31.89	24.18	12.80
2005									
Males	17.80	13.08	7.03	35.87	29.18	14.83	21.01	16.37	7.65
Females	30.21	22.23	11.34	50.10	37.35	20.59	31.07	23.80	13.45
2006									
Males	25.57	18.80	9.25	30.31	21.31	11.79	28.13	21.50	11.13
Females	29.54	23.98	11.48	44.71	32.88	17.43	40.50	32.00	16.33
2007									
Males	18.85	13.92	6.36	33.28	24.87	12.87	18.86	14.63	6.09
Females	28.10	21.26	10.20	42.58	33.23	18.05	28.99	21.47	9.83

Table 7 (cont.)

Rates of Separation (Sec/km) for NCAA by Year, Gender, and Level

	DI			DII			DIII		
Year	*5 - 95%*	*10 - 90%*	*25 -75%*	*5 - 95%*	*10 - 90%*	*25 -75%*	*5 - 95%*	*10 - 90%*	*25 -75%*
2008									
Males	17.29	14.10	6.43	25.28	20.20	9.70	15.64	12.54	6.92
Females	25.71	19.77	9.53	40.42	31.45	15.04	28.73	24.07	12.18
2009									
Males	21.09	15.90	7.22	31.85	23.04	11.36	21.04	17.08	8.47
Females	28.39	20.32	9.48	42.33	31.16	15.43	31.15	26.62	13.57
2010									
Males	18.11	14.87	7.98	27.04	21.84	12.95	19.99	14.70	7.01
Females	26.47	20.86	10.81	42.61	33.21	17.28	25.92	20.87	9.75
2011									
Males	16.97	13.65	6.85	27.12	22.42	12.10	16.92	13.48	6.83
Females	26.50	19.93	10.44	46.38	36.48	17.49	28.37	21.37	10.57

Table 8
Rates of Separation (Sec/km) for NAIA by Year and Gender

Year	*5 - 95%*	*10 - 90%*	*25 -75%*
2005			
Males	27.27	21.07	10.50
Females	38.16	29.55	14.46
2006			
Males	30.38	21.86	10.69
Females	39.80	29.89	14.14
2007			
Males	23.47	17.53	8.18
Females	35.22	30.55	14.91
2008			
Males	32.10	24.13	11.25
Females	53.70	39.98	17.20
2009			
Males	35.73	25.10	12.63
Females	55.40	42.20	18.40
2010			
Males	35.73	25.10	12.63
Females	55.40	42.20	18.40
2011			
Males	30.72	21.05	10.00
Females	43.68	34.72	14.00

Table 9
Summary of Independent t-tests for Rates of Separation (Sec/km) by Gender and Level

	5 - 95%					*10 - 90%*					*25 -75%*				
Level	Males	Females	*t*	*df*	*p*	Males	Females	*t*	*df*	*p*	Males	Females	*t*	*df*	*p*
DI	19.43	28.39	4.13	24	< .001	14.87	21.54	4.51	24	<.001	7.39	10.68	3.20	24	.004
DII	31.13	44.55	2.98	24	.007	23.73	33.90	3.75	24	.001	12.29	17.17	3.29	24	.003
DIII	20.59	30.80	1.27	24	.216	15.96	24.03	1.34	24	.193	7.92	11.93	1.21	24	.239
NAIA	31.07	44.83	1.18	12	.263	22.39	34.56	0.49	12	.634	10.77	15.56	1.53	12	.152

Statistically Appropriate Distances

The results of the statistically appropriate distance analyses are presented in Tables 10 and 11. The longest statistically appropriate distance to emerge for women was 9.34 km based on the $RS_{25th-75th}$ of the 1999 DI races. In contrast, the shortest statistically appropriate distance for the women to emerge was 5.21 kilometers based on the $RS_{10th-90th}$ of the 2008 DIII races. No analysis revealed the women should run as far as men or as low as half the distance as men. The overall averages for each level of the statistically appropriate distances were as follows: DI: 6.91 km; DII: 7.16 km; DIII: 6.67 km; and NAIA: 6.93 km. The mean value within the analysis was 6.86 km, which suggests if women run 68.6 % the race distance as compared to men, then they would achieve approximately equal absolute variation as men. These results lend support for the third hypothesis that, under the equivalent variation criteria, women should run further than they currently do, but still not as far as the men run currently with the exception of DIII.

Table 10

Statistically Appropriate Distances (km) for Females—NCAA

	DI				DII				DIII			
Year	*5 - 95%*	*10 - 90%*	*25 -75%*	*M*	*5 - 95%*	*10 - 90%*	*25 -75%*	*M*	*5 - 95%*	*10 - 90%*	*25 -75%*	*M*
1999	7.43	7.81	9.34	8.19	6.61	7.52	7.90	7.34	6.50	6.48	6.09	6.35
2000	5.43	6.05	5.64	5.37	9.11	7.09	7.88	8.03	7.36	8.37	7.41	7.71
2001	6.85	6.84	7.30	7.00	7.13	6.93	6.61	6.89	6.95	7.01	8.02	7.33
2002	7.48	7.13	6.93	7.18	6.71	7.02	7.14	6.95	6.34	6.29	6.36	6.33
2003	7.30	7.09	6.93	7.11	6.68	7.31	7.94	7.31	7.05	6.58	7.81	7.15
2004	7.37	6.83	6.06	6.75	6.69	6.80	6.24	6.58	6.55	6.53	6.77	6.62
2005	5.89	5.89	6.19	5.99	7.16	7.81	7.20	7.39	6.76	6.88	5.69	6.44
2006	7.24	6.79	7.42	7.15	6.78	6.48	6.76	6.67	6.94	6.72	6.81	6.82
2007	6.71	6.55	6.24	6.50	7.82	7.48	7.13	7.48	6.51	6.81	6.20	6.51
2008	6.72	7.13	6.74	6.87	6.25	6.42	6.45	6.38	5.44	5.21	5.68	5.44
2009	7.43	7.82	7.62	7.62	7.52	7.39	7.36	7.43	6.75	6.42	6.24	6.47
2010	6.84	7.13	7.39	7.12	6.35	6.58	7.49	6.81	7.71	7.04	7.19	7.32
2011	6.41	6.85	6.57	6.61	5.85	6.15	6.92	6.30	5.96	6.31	6.46	6.24
Mean	6.85	6.92	6.95	6.91	6.97	7.00	7.16	7.04	6.68	6.67	6.67	6.67

Table 11
Statistically Appropriate Distances (km) for Females—NAIA

	Percentiles			
Year	5 - *95%*	*10 - 90%*	*25 -75%*	*Mean*
2005	7.15	7.13	7.27	7.18
2006	7.63	7.31	7.56	7.50
2007	6.66	5.74	5.49	5.96
2008	7.90	7.42	7.66	7.66
2009	5.98	6.03	6.54	6.18
2010	6.45	5.95	6.86	6.42
2011	7.03	6.06	7.14	6.75
Mean	6.97	6.52	6.93	6.81

CHAPTER FIVE: DISCUSSION

The purpose of this thesis was to analyze the variation of finishing times for collegiate cross country national championships based on gender and included three primary analyses that: (a) compared a *relative* measures of variation (i.e., CV and RSs); (b) compared an *absolute* measure of variation (i.e., IR differences); and (c) computed a proposed competition distances that would make the variation of male and female races approximately equal. Most of the findings supported the predictions made in the study's hypotheses.

This study achieved its purpose and revealed there was a difference in the variation of finishers between men's and women's races within collegiate cross country national championships. The analyses revealed: (a) women's races showed a greater *relative* variation than men's and (b) men within DI and DII showed a greater *absolute* variation in races than women. The *relative* variation was captured by the comparison of CV and RSs, both of which revealed women's races tend to have a greater finishing spread relative to the race distance as compared to men's races. The *absolute* variation was illustrated by the comparison of the three IRs (25^{th} - 75^{th}, 10^{th} - 90^{th}, and 5^{th} - 95^{th}). It was revealed that within DI and DII, finishers in men's races were further apart in time at the end of the race than women. This finding partially confirmed the second hypothesis; however, the same tests for DIII and NAIA did not reach significance. A simple examination of the DIII IRs in Table 4 suggests that most of the women's ranges exceed that of the corresponding men's ranges despite only running a course 75% of the men's.

The first hypothesis examined whether women's races resulted in a greater *relative* variation in finishing times than men's races. The results of the comparison between the CV between men and women indicated that women's races tend to have a greater *relative* variation than men's races. In fact, when the corresponding men's and women's races were paired with their corresponding year and level, there was only one year and level that resulted in a higher CV for the men's race (i.e., DII for 2000). This finding further supports the first hypothesis.

A significant difference also emerged between the men's and women's RSs, which supports the notion that participants in women's races are more spread apart relative to the race distance than participants in men's races. This finding suggests that under the metric of *relative* variation, it is statistically justified for women to compete over a shorter distance than men at the collegiate level. Also, this finding reinforces the findings from Deaner (2006a, 2006b) comparing men and women to an elite standard, as well as those from Frick (2011) comparing men's and women's all-time best marks.

The second hypothesis anticipated that men would have a greater *absolute* variation in finishing times than women and utilized time differences in IRs of 25^{th} - 75^{th}, 10^{th} - 90^{th}, and 5^{th} - 95^{th}. These analyses partially supported the hypothesis that men finished further apart (i.e., *absolute* variation) from each other than women. For DI and DII, the field finishes further apart for men when compared to the corresponding part of the women's field even though women show a higher *relative* variation. Specifically, the difference between the competition distances for men and women is greater than the variation difference between men and women. This finding supports the conclusion that current differences in competition distance between men and women are not statistically justified for DI and DII; that is, if the goal of running different competition distances is to have equal variation. For DIII and NAIA, the current competition distances appear to be justified.

Hypothesis three predicted the difference in competition distances between males and females would be greater than what can be explained by *relative* variation. If the goal of a competition distance is to spread the men's and women's fields out equally, then the distances currently run within DI and DII are not appropriate. The results support this hypothesis because overall the statistically appropriate distance computations suggest women should run 68.6% of the competition distance for men. This figure represents a 14.3% longer distance for women at the DI and DII levels and 9.8% longer for NAIA. The one exception to an increased distance is at the DIII level where women run 6 km and men run 8 km. In other words, women run 75% of the men's distance, the smallest competition distance gap at any level. This analysis suggests that the competition distance gap within DIII should increase instead of decrease (i.e., the women's competition distance get shorter or the men's competition distance get longer).

The secondary purpose of this study was to determine a more statistically appropriate competition distance for the men and women to run. As noted previously, women should run 68.6% of the men's distance in order to make the variations between the men's and women's races roughly equivalent. This distance equates to a 6.86 km race for women to the men's 10 km race or an 8.75 km race for the men to the women's 6 km. Ultimately, the findings lend support for the discrepancy in competition distances run for men and women; however, the justification of finish variability does not support fully the current distances run in DI and DII because there is a greater discrepancy in the competition distances than there is in the variation differences. For DIII and NAIA, the IR analysis appears to statistically support the current distances run.

Women tend to run approximately 12.4% slower than men (Coast et al., 2004) and this fact may be partially responsible for the results from this study. It may not be the distance that most influences the *relative* variation but the time spent competing. If time and not distance is the main factor for race variation, given that women are running for a longer time for each kilometer than men, it would be expected that their finishing times would show around a 12.4% difference in absolute variation. In other words, one might expect men's and women's finishing time variation to be equal at the same distances that would result in equal overall finishing times. Thus, approximately 12.4% of the variability is due to the fact that women tend to be slower than men. The fact that the proposed formula suggests women should run a distance 68.6% of the men, a 31.4% difference, means that the variability is due to more than just the fact that women tend to run a bit slower.

A number of variables may contribute to the gender differences found within this study. Participation numbers are different for males and females with more males competing than females at the lower levels of competition. If as many females competed as males, then it may be expected that female races would show less *relative* and *absolute* variation; whereas, if fewer males competed in cross country, one may expect male races to show more of a relative and absolute variation. The reason participation numbers may affect the variability of races is because when a higher number of people participate in an event, the more likely it is that less talented individuals will not make it to higher levels of competition. Furthermore, if the talent pool no longer contains the less talented individuals then conceptually, it would make sense that the variation within that talent pool will likely decrease.

A number of studies have shown that males tend to be more competitive in sport or seek out competition more often than females (Cashdan, 1998; Gill, 1986, 1994; Niederle & Vesterlund, 2007; Stevens et al., 2002). Goal orientations may be partially responsible for the gender difference shown within this study. Males tend to be more win oriented than females and females tend to be more goal oriented than males (Gill, 1986, 1994; Stevens et al., 2002). Consider, for example, if a sample of individuals exists who tend to be more win oriented (i.e., tend to measure their success by how well they performed against others) than another group that is goal oriented (i.e., tend to measure their success by comparing their performance to their own personal previous performances), it is anticipated the win oriented individuals would tend to have more closely contested competitions if they were to run a cross country race. The reason one might expect more closely contested races from the sample that measures success by social comparison is that the win oriented population will stick closer together for a longer period of time because their success depends on it.

Effort levels and group dynamics have been shown to contribute to gender difference and may influence the variability of finishing times within cross country races. Men tend to give more to a group when that group is in direct competition with another group (Van Vugt et al., 2007). In cross country running, where teams (or groups) run against each other, it is plausible that men put forth more effort than women in a cross country race. A group of runners putting forth higher levels of effort would likely stay together longer during the race and finish closer together. Suver (2009) provided two quotes that are representative of each gender's view towards competition within the sport of cross country. Female cross country DI All American, Mattie Bridgmon, stated:

> …it's an individual sport with a team aspect, I like it because I can see my own performance improvements instead of depending on the team for me to win, the team helps, but in the end it comes down to myself performing. (p. 5)

Bridgmon clearly indicates she is primarily concerned with her own performance over her team's performance. Male cross country DI national champion Galen Rupp stated in an interview, "With a real close group of guys, you don't want to let them down, and mostly you do not want to let your teammates down" (p. 15). For Rupp, the fact that his teammates were counting on him was a greater motivator than his own personal expectations. If both of these explanations are representative of other males and females during competition, Bridgmon and Rupp described what I believe may be a common difference in attitude between men and women.

Differences in participation rates, competitiveness, goal orientation, and group effort levels, combined with factors such as risk taking may explain why women's collegiate cross country races tend to show more variation than men's collegiate cross country races. If women's finishes are relatively more spread out than men because, as Frick (2011) suggests, women have fewer incentives than men; then, it should not happen within the sport of cross country in the NCAA, especially, at the DI level. There is actually more scholarship money for women in DI track and field (cross country is considered part of track and field) than there is for men (*NCAA Division I Manual*, 2012, p. 212-213). DI schools are allowed up to 18 scholarships for women in track and field and up to 12.6 for men (*NCAA Division I Manual*, 2012, p. 212-213). Given that DI women have more of an incentive than DI men in the form of scholarship money, if the incentive hypothesis is correct, it would be expected that women would finish closer together as a group than men, not the opposite. Because of these incentive differences, I believe this study provides some evidence against the differing incentives hypothesis proposed by Frick (2011).

The results of this study align with the results from Deaner (2006a, 2006b) and Frick (2011). In Deaner's first study (2006a), he found that females from the high school, college, and elite levels all tended to have fewer athletes perform close to the best performance of the season. Deaner's (2006b) second study found that within U.S. road races, fewer females finish within a given percent of an elite standard and also women tend to win races by a larger margin than men. These results suggest that females might also show more varied finish times overall than males as was seen within this study. Frick's (2011) study showed that men's all-time performance lists have performances closer together than the women's lists. Frick's (2011) and Deaner's (2006a, 2006b) studies suggest the same result found within the current study of comparing men's and women's cross country races. The fact that women showed greater variation than men within race finishing times is consistent with much of the previous scientific literature.

Limitations

This study was limited to collegiate cross country national championships within the U.S. cross country races from the same level of competition in other countries may not show the same characteristics as the races within this study. High school or elite level competitions may not show the same characteristics. Likewise, if the men and women ran the same distances for the competition, it is possible that the results of this study would not hold. Therefore, the results of this study do not necessarily generalize to other levels of competition.

What remains unclear about variation in finishing times in collegiate cross country is whether or not changing the distance for women would change the variation in finishing times accordingly. This question may have an inherent answer based on the results of the 1999 Women's DI race, the last year the women competed over 5 km. Similarly, 2001 was the last year women in DIII competed over 5 km at their national championship. Given that the highest statistically appropriate distances emerged from the 1999 DI race, it appears that increasing the competition distance in the 2000 season may have increased also the relative variation in finishing times for the women. Likewise, the proposed women's distances suggested by the formula from DIII in 1999 through 2001 represent some of the higher proposed distances from that division. Those changes in the proposed distances imply that the increase in distance for women slightly increased the *relative* variation for women. Also, since 2002, DIII had the smallest competition distance gap of any level and the statistically appropriate distance analyses suggested that DIII should have the largest competition distance gap of any level, which may be the result of relative variation increasing with the increase of competition distance. An additional increase in competition distance would possibly have the same effect on participant's relative finishing variation of a race. Of course, without a statistical test comparing the years before and after the change in the women's competition distance, nothing can be stated to any degree of certainty.

This study does not provide information to discern if increasing women's competition distances to 68.6% of men's competition distances will in fact make the absolute variations equivalent. It does appear, however, that increasing the women's competition distance would increase the absolute variation in women's finishing times.

Increasing the competition distance likely would increase the relative variation within a race. This notion is forwarded because the further the competition distance, the less likely a track and field middle distance runner will be competitive. Currently, there are few male 800 m specialists who are competitive in cross country over the 10 km distance. The 10 km distance favors an athlete who is better at the longer track distances (i.e., the 5 km and 10 km). Given that women only have to run 5 or 6 km, it is much more likely that an 800 m specialist would be competitive because a 6 km distance is not as much of an increased distance from 800 m as a 10 km race. The further the race distance, the greater the likelihood that a smaller cross section of athletes would be competitive at that distance and thus result in increased levels of relative variation.

Future Research

There are a number of possibilities for future research on this topic. A comparison of boys and girls at the high school level, such as state championships, would be worthy of an analysis especially because most states have boys and girls run the same distance. There are not as many elite level competitions for cross country as there are for collegiate athletes but past cross country data from world championships could be analyzed. A comparison of track and field events would be worth analyzing because track races are different from cross country races; however, it might be more difficult because each track event has far fewer participants than a cross country race.

Other individual sports could be analyzed to determine whether large cycling, swimming, or triathlons show the same pattern. Running road races could be analyzed and I imagine the results would be the same, given the results of Deaner (2006b) and Frick (2011).

Additionally, it might be interesting to study the noncompetitive athletes in road races (i.e., athletes who have a goal just to finish) to determine if those athletes have any gender difference. There would be no surprise if females showed a smaller variation than males in these types of events because noncompetitive females might be more likely to do a road race for social reasons than noncompetitive males. It is possible that noncompetitive females would be more likely to stay together than the males. Another reason why variation might be reversed in noncompetitive athletes is because males tend to have a potential for a slightly better elite performance than females do, so the male athlete has farther to be behind his competitive male counterparts than a female does her competitive female counterparts.

Examining races of different distances in order to determine if the distance of the race has an effect on the *relative* variation is another direction worth exploring. This study's methodology implies that the distance of the race will not affect the relative variation of a race. However, it is unknown if the distance of a race has an effect on the *relative* variation. A study done in order to find the answer would be helpful.

More research is warranted to examine gender differences in areas such as training volumes, participation levels, psychology, and other factors that may impact distance runners competing over a shorter distance versus a longer distance. Also, before changing the competition distance, there is a need to understand current barriers that exist in keeping women from competing over a longer distance, such as attitudinal and structural barriers. Research into the optimal spread for a race should be done, such as how much spread is too much for a race to become less interesting and exciting to watch, and how little of a spread is too little for race officials to determine a clear order and for participants to not feel like the race is too crowded.

Other Considerations

One suggestion from this study is that it might be appropriate for women, within DI and DII, to compete over a longer distance than is currently run. In order for the current competition distances to change, several things should be taken into consideration. The first consideration is that of runners' preferences: Do collegiate women want to compete over a longer distance than they do right now or do they actually prefer the current competition distance? In my experience within the sport of cross country, it is probably the case that many, but not all, women like the current competition distance and would be against an increase in the competition distance. A second consideration has to do with college cross country coaches: Do collegiate distance coaches prefer the current competition distance or would they like the distance increased? In 2011, 10 out of 50 of the U.S. states had high school girls compete over a shorter distance than that of the boys. The main reason why many of those states resisted lengthening the distance girls ran was because the coaches feared that having girls run as far as the boys will decrease the participation numbers for girls (Parish, 2012). It may not be the case that increasing the competition distance for women at the collegiate level will lower the participation rates in college but coaches may have some concerns about the distance being changed. Coaches may have concerns related to revising their training systems to better adapt their runners to a longer distance, such as a higher training volume, which will increase the likelihood of injury or not wanting to run in as many competitions because a longer race requires more time to recover.

One consideration that cannot be ignored is the logistical concern of making courses the right length. I am unaware of any cross country courses that are 6.86 km or even 7 km. If the women’s distance of 6 km were to increase, it would likely increase to 8 km instead of any other distance because 8 km is already a common distance run and many courses are laps of 2 km loops making any distance divisible by 2 km easy to run.

If the purpose of the competition distance discrepancy in cross country is to separate the fields of competition equally for men and women, then having men and women run different distances is justified. Currently, there is a greater discrepancy between the competition distances than the amount of difference in variation within DI and DII. Based on the findings of this study, it is suggested that women should run a greater distance than they currently do in the NCAA DI and DII. It may be concluded that lengthening the competition distance for women within DI and DII should be considered seriously because of the results found within this study. I would not argue for women to suddenly run the same distance as the men but as the analysis suggests, a distance that is longer than the current distance but still a bit shorter than the men's distance is recommended: 7 km for Divisions I and II would be a good distance given the results of this study even if it is not the most practical distance. It is proposed that women run a farther distance instead of men running shorter because of my own personal experience in college cross country. As a two time participant in the men's DI national championship race, I cannot imagine making that race more tightly packed at the finish. The women's runners are currently running closer together at the end of the race so spreading the women out is a much better idea than packing the men closer together.

Conclusions

There are a couple of conclusions that can be drawn from this study. The first conclusion is that there is a possible justification for women to run a shorter distance than men within collegiate cross country races. The second conclusion is that given the current competition distances within DI and DII, it is unlikely that such a justification is reason enough for the entire discrepancy in competition distances. Women should compete at a distance farther than their current competition distance, at least for DI and DII. This study supports the notion that women within DI and DII should compete over a distance farther than the current competition distances. All other distance running venues outside of cross country have women and men compete over the same distance. However, this study does justify women racing a shorter distance than men, in cross country, if one accepts the criteria of equal variation for men and women. However, this criteria of equal variation does not justify the quantity of the difference in competition distance in all cases and if anything women and men should be given the benefit of the doubt and compete at distances slightly closer together than farther apart from what the analysis of this study suggests.

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