Assessment of Risk Factors for Stress Fractures and Future Osteoporosis in Female Collegiate Cross Country Runners

by

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ABSTRACT

The purpose of this study was to investigate female cross country runners' risk factors for stress fractures and future osteoporosis. Subjects for this study consisted of 16 female collegiate cross country runners (M = 19.9 years, SD = 1.54) at a Division III university. A nutrition assessment consisting of a 3-day food record and measurements of height, weight, and heel bone density using a Sahara Clinical Bone Sonometer was conducted on each athlete. Each athlete was also asked several questions relating to factors that affect bone health including her ethnicity, menstrual history, and use of medications including supplements and birth control.

This study found that essentially all of the female cross country runners in this study are from a high risk gender and ethnic group. This study revealed that 43.25% of the cross country runners had risk factors for osteoporosis based on their weight and dietary calcium intake. Twenty-five percent of the cross country runners experienced menstrual dysfunction in the past year which is a risk factor for stress fractures and osteoporosis. This study also revealed that all

of the cross country runners in this study had a normal heel bone mineral density T-score and that 81.25% of the cross country runners took a multivitamin and mineral supplement at least some of the time which may help a number of the cross country runners meet the recommended calcium intake and help protect against osteoporosis.

In conclusion, it appears that nutrition education in regards to bone health would be beneficial for this population because early detection of risk factors can lead to early treatment which may aid in improving cross country runners' performances and health.

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TABLE OF CONTENTS

....Page

ABSTRACT ii

Acknowledgements iv

Chapter I: Introduction 1

Statement of the Problem 4

Research Questions 4

Definition of Terms 5

Assumptions and Limitations 6

Chapter II: Literature Review 7

The Female Athlete Triad 7

Osteoporosis 8

Risk Factors for Osteoporosis 9

Gender 10

Ethnicity 10

Body Structure 11

Menstrual History 12

Oral Contraceptives 14

Dietary Practices 16

Calcium 17

Supplements and Medications 20

Exercise 21

Bone Mineral Density 21

Chapter III: Methodology 24

Subject Selection and Description 24

Instrumentation 24

Data Collection Procedures 25

Data Analysis 26

Limitations 27

Chapter IV: Results 28

Table 1: Summary of Subject Characteristics for Interval Data 28

Age, Gender, and Ethnicity 29

Body Structure and Body Weight 29

Bone Mineral Density 30

Menstrual Cycle 31

Energy Intake 32

Calcium Intake 32

Figure 1: Percent of Cross Country Runners with Risk Factors for Osteoporosis 33

Medications and Supplements 34

Correlations 34

Chapter V: Discussion 35

Limitations 35

Discussion 36

Conclusion 38

Recommendations for Future Studies 39

References 40

Appendix A: Consent Form 49

Appendix B: 3-Day Food Record 51

Appendix C: Nutrition Assessment Form 52

Chapter I: Introduction

The number of female athletes has increased significantly since the passage of Title IX in 1972 with the number of female college athletes increasing from 31,852 in 1972 to over 150,000 in 2002 (*National Education Association: Title IX*, 2006). As the number of female athletes continues to grow, it becomes important to address issues unique to female athletes for both their performance and their health. One concern that has become quite prevalent in recent years is that of the "female athlete triad." The "female athlete triad" is an athlete who is experiencing disordered eating, menstrual irregularity, and osteoporosis/osteopenia (Cobb et al., 2003).

Osteoporosis, one aspect of the female athlete triad, is also a major health threat for 44 million Americans, 80% of whom are women (*National Osteoporosis Foundation: Fast facts*, 2006). And while osteoporosis is a debilitating disease, medical experts agree that it is highly preventable and treatable. In 2002, President George W. Bush proclaimed the years 2002 to 2011 as the *Decade of the Bone and Joint* making bone health a priority (Carmona, 2006). Thus, with bone health being made a priority, it seems prudent that research efforts be made in this area.

Certain factors do increase the likelihood of developing osteoporosis, including being female, being thin and/or having a small frame size, and being Caucasian or Asian. Cross country runners tend to be thin since leanness and/or low body weight is considered an important factor in this sport. Also, in the 2003-2004 academic year, approximately 90 percent of National Collegiate Athletic Association (NCAA) Division III women cross country runners were Caucasian or Asian (Bray, 2005). Thus, based on these risk factors, female cross country runners seem to be at increased risk for future osteoporosis.

Low bone mass puts athletes at an increased risk for stress fractures and also for future osteoporosis. What is particularly frightening about decreased bone mass is that bone loss occurs without symptoms; therefore, it is impossible for people to know their bone status unless they have their bone mass density measured or after they have experienced a fracture as a result of weak bones. Fredericson, Salamancha, and Beaulieu (2003) showed the relationship between low bone mass and stress fractures in a study that discovered 9 out of 12 female distance runners who experienced stress fractures were also experiencing either osteopenia or osteoporosis based on their T-score value.

While low bone mass puts people at an increased risk for stress fractures and osteoporosis, there are several factors that can help increase bone mineral density. Moderate physical activity can help increase bone mineral density by favoring bone mineralization and reducing the rate of bone loss (Quintas, Ortega, Lopez-Sobaler, Garrido, & Requejo, 2003). Weight-bearing and resistance training exercises are particularly associated with higher bone densities. Creighton, Morgan, Boardley, and Gunnar Brolinson (2001) reported that athletes involved in the greatest weight-bearing sports had higher bone mass density than those athletes involved in non-weight-bearing activities and sedentary individuals. A study by Risser et al. (1990) showed that female volleyball and basketball players had significantly higher bone density than swimmers and non-athletes.

Despite weight-bearing physical activity being beneficial in preventing osteoporosis, several studies have reported that female distance runners, despite the nature of their weight-bearing activity, do not possess comparably high bone mineral density (Burrows, Nevill, Bird, & Simpson, 2003; Winters-Stone & Snow, 2004). Decreased bone mineral density may therefore be an area of concern for female cross country runners.

Another important factor in the development and maintenance of healthy bones is having good dietary practices, particularly with adequate calcium intake. Many Americans, including female collegiate athletes, fail to consume enough calcium to meet the daily calcium recommendations (Ervin, Wang, Wright, & Kennedy-Stephenson, 2004). The current recommendations for calcium, provided in the Dietary Reference Intakes, are 1,300 milligrams per day for 14 to 18 year old females and 1,000 milligrams per day for adult women 19 to 30 years old (Food and Nutrition Board, 1997). For females in an estrogen deprived state, such as athletes experiencing menstrual dysfunction, 1,500 milligrams of calcium per day is recommended in an attempt to maintain calcium balance and help prevent osteoporosis (Committee on Sports Medicine and Fitness, 2000). Adequate amounts of calcium are essential for bone development and maintenance. The consumption of adequate amounts of calcium during adolescence and young adulthood is particularly important for females because it is positively associated with achieving peak bone mass (Anderson, 2004). Achieving peak bone mass may provide added protection against fractures and osteoporosis later in life.

While good dietary practices and moderate physical activity have been shown to be beneficial in preventing osteoporosis, poor dietary practices and excess training may contribute to lower bone mass density by leading to menstrual dysfunction. J. Harlan (personal communication, August 10, 2006), a head women's collegiate cross country coach for 11 years, stated that female college cross country runners typically run between 30 and 70 miles per week and many do not consume enough calories to replace what they burn in their workouts. A study of 30 female distance runners reported that 93% of the athletes under consumed calories, 60% had menstrual irregularities, and 60% had low spinal bone loss (Clark, 2001). It is well documented that athletes experiencing oligomenorrhea or amenorrhea usually have lower bone mass density than those with normal menstrual cycles. Amenorrhea, especially when combined with low calcium intake, can reduce bone mineral content, thus increasing the risk of stress fractures and osteoporosis later in life (Thompson & Gabriel, 2004).

By examining the risk factors for osteoporosis, it appears that female collegiate cross country runners may be at an increased risk for osteoporosis. Thus, an assessment of the athletes' risk factors for stress fractures and future osteoporosis would be a prudent step in addressing an issue particularly unique to female athletes. By determining which risk factors for osteoporosis are most prevalent in college female cross country runners, education efforts can be focused in areas that will most readily help in the prevention of stress fractures and future osteoporosis. Also, early detection of risk factors for osteoporosis can lead to early treatment, which may aid in improving athletes' performances and health.

Statement of the Problem

The purpose of this study was to investigate a NCAA Division III university women's cross country team's risk factors for stress fractures and future osteoporosis. During the cross country season in the fall of 2006, a nutrition assessment was conducted on each athlete. The nutrition assessment consisted of a 3-day food record and measurements of height, weight, and heel bone mineral density was obtained from each athlete. Each athlete was also asked several questions related to factors affecting bone health.

Research Questions

This study will address the following research questions:

1. Are collegiate female cross country runners at an increased risk for stress fractures and future osteoporosis based on assessing several risk factors for osteoporosis?

2. Are collegiate female cross country runners at increased risk for future osteoporosis based on their weight?

3. Do collegiate female cross country runners have decreased bone mineral density based on their heel bone density T-score value?

4. What is the prevalence of menstrual dysfunction among NCAA Division III collegiate female cross country runners?

5. Do collegiate female cross country runners consume the recommended amount of daily calcium?

6. Do collegiate female cross country runners have protective factors against osteoporosis?

Definition of Terms

For clarity of understanding and for conveying the operational definition used by the researcher, the subsequent terms are defined as follows:

Amenorrhea is the absence of menstruation. For this study, athletes were classified as amenorrheic if they had zero to three menstrual periods in the past year.

Cortical bone, also known as compact bone is extremely hard/dense and forms the surface of bones, contributing 80% of the weight of the human skeleton.

Eumenorrhea is normal menstruation. For this study, athletes were classified as eumenorrheic if they had 10 to 14 menstrual periods in the past year.

Female athlete triad is the combination of disordered eating, menstrual irregularity, and osteoporosis/osteopenia in physically active girls and women.

Oligomenorrhea is infrequent menstruation. For this study, athletes were classified as oligomenoreic if they had four to nine menstrual periods in the past year.

Osteopenia is abnormally low bone density clinically defined as a T-score value of -1.0 to -2.5.

Osteoporosis is a skeletal disease characterized by low bone density with a subsequent increase in bone fragility and susceptibility to fractures. It is clinically defined as a T-score value of less than -2.5

Trabecular bone, also known as cancellous bone is spongy and makes up the bulk of the interior of most bones, including the vertebrae. Its main function is to support the body, protect organs, provide levers for movement, and store minerals.

Assumptions and Limitations

In examining this research, it is important to consider several underlying assumptions and limitations. First, it was assumed that the 3-day food records completed by the athletes were accurate and that they were not influenced by perceptions of what they felt they should be eating or by inaccurate estimates of portion sizes consumed. Second, it was assumed that the method for assessing bone density was an accurate reflection of the athletes' actual bone density. It was also assumed that the athletes answered all questions honestly. Limitations to the study included the accuracy of the 3-day record used to evaluate the athletes' diets because of day-to-day and seasonal variation in peoples' diets. Also, the findings in this study may not apply to other female collegiate cross country runners. Finally, there could be additional variables that this study did not look at that could alter the results and conclusions of this study.

Chapter II: Literature Review

This chapter looks at the increase in the number of female athletes and health concerns that are unique to females. This chapter then goes on to examine risk factors for osteoporosis with a focus on female cross country runners. The factors that affect bone health looked at in depth in this chapter include: gender, ethnicity, body structure and weight, menstrual history, dietary practices with a focus on calcium, and exercise.

The number of female athletes has increased significantly since the passage of Title IX, the federal law that has expanded opportunities for women in sports and other aspects of education (*National Education Association: Title IX*, 2006). Prior to the passage of Title IX the number of high school girls playing competitive sports was less than 300,000 (*Information: Facts on Title IX & Athletics*, 2007). By 2001, this number grew to 2.78 million. The number of female college athletes increased from 31,852 in 1972 to over 150,000 in 2002 (*National Education Association: Title IX*, 2006). Sports participation for girls has been shown to have significant health benefits physically, psychologically, and socially (Lopiano, 2007). However, the vast and growing number of female athletes has also brought about health concerns that are unique to female athletes.

The Female Athlete Triad

One health concern that is unique to female athletes is that of the "female athlete triad." The "female athlete triad" is typically defined as an athlete who is experiencing disordered eating, amenorrhea, and osteoporosis (Sangenis, 2006). However, Cobb et al. (2003) uses a more loose definition of the "female athlete triad" as an athlete who is experiencing disordered eating, menstrual irregularity, and osteoporosis/osteopenia. While both definitions of the "female athlete triad" are looking at basically the same three interrelated conditions, the looser definition appears to focus more on identifying athletes at increased health risk early whereas the more strict definition may not recognize athletes at increased health risk until irreversible damage has been done.

The exact prevalence of the "female athlete triad" is unknown; however, when broken down into the individual parts of the "female athlete triad" Hobart and Smucker (2000) found studies that reported disordered eating behavior in 15 to 62 percent of female college athletes. Hobart and Smucker also found that amenorrhea has been reported in 3.4 to 66 percent of female athletes, compared with only 2 to 5 percent of women in the general population. Both disordered eating and amenorrhea are risk factors for the third aspect of the "female athlete triad," osteoporosis.

Osteoporosis

Osteoporosis, one aspect of the "female athlete triad," is a disease characterized by low bone mass in which the bones become fragile and more susceptible to fracture *(Osteoporosis: Definition and classification*, 2001). The bones most typically fractured due to osteoporosis are the hip, spine, and wrist; however, any bone can be affected (*National Osteoporosis Foundation: Fast facts*, 2006). For female athletes, osteoporosis is most immediately a concern for stress fractures that may ruin their athletic career.

As of 2002, osteoporosis was a major health threat for 44 million Americans (*Eight common myths about osteoporosis*, 2002). By the year 2020, the National Osteoporosis Foundation expects osteoporosis and low bone mass to affect over 61 million people in the United States. Not only is osteoporosis a serious health threat for so many people, it is also very costly. In 2002, it was estimated that the national direct expenditure for osteoporotic hip fractures was $18 billion, and this cost rises each year (*National Osteoporosis Foundation: Fast facts*, 2006). In 2001, it was estimated that each hip fracture costs $40,000 (*Eight common myths about osteoporosis*, 2002).

Osteoporosis is often referred to as a "silent disease" because bone loss occurs without any symptoms (*National Osteoporosis Foundation: Fast facts*, 2006). In fact, many people do not know that they have osteoporosis until they get an osteoporotic fracture. Thus, it is safe to say that osteoporosis is an under recognized and under treated disease. And while osteoporosis is a debilitating disease, medical experts agree that osteoporosis is highly preventable and treatable.

In 2002, President George W. Bush proclaimed the years 2002 to 2011 as the *Decade of Bone and Joint* making bone health a priority (Carmona, 2006). Proclaiming the years 2002 to 2011 as the *Decade of Bone and Joint* seems to be a prudent step in preventing and treating osteoporosis. Another step that seems important in preventing and treating osteoporosis is to identify risk factors for osteoporosis in individuals and among high risk groups before they become debilitating and costly.

Risk Factors for Osteoporosis

The National Osteoporosis Foundation identifies the following as risk factors for osteoporosis: personal history of fracture after age 50, current low bone mass, history of fracture in a first degree relative, being female, being thin and/or having a small frame, advanced age, a family history of osteoporosis, estrogen deficiency as a result of menopause, abnormal absence of menstrual periods, anorexia nervosa, low lifetime calcium intake, vitamin D deficiency, use of certain medications including corticosteroids, presence of certain medical conditions, low testosterone levels in men, an inactive lifestyle, cigarette smoking, excessive use of alcohol, and being Caucasian or Asian (*National Osteoporosis Foundation: Risk factors*, 2006). The pages that follow will examine the risk factors particularly relevant to female collegiate cross country runners more in depth.

Gender

Females are at a higher risk of developing osteoporosis because in general females have less bone tissue then men and also because females lose bone more rapidly then men due to changes involved with menopause (*National Osteoporosis Foundation: Risk factors*, 2006). The National Osteoporosis Foundation states that approximately 80 percent of those affected by osteoporosis are women (*National Osteoporosis Foundation: Fast facts*, 2006). This translated to approximately 30 million women with osteoporosis or at risk for developing osteoporosis in 2002 and approximately eight million women with osteoporosis. According to the 1999-2000 National Collegiate Athletic Association (NCAA) Gender-Equity Report, just over 50 percent of Division III cross country runners are females (DeHass, 2002). Therefore, based on gender alone just over 50 percent of Division III cross country runners have at least one risk factor for osteoporosis.

Ethnicity

Caucasian and Asian women are more likely to develop osteoporosis than other ethnic groups (*National Osteoporosis Foundation: Risk factors*, 2006). In fact, 20 percent of non-Hispanic white and Asian women aged 50 years and older are estimated to have osteoporosis with 52 percent estimated to have low bone mass (*National Osteoporosis Foundation: Advocacy News and Updates*, 2006). However, African American and Hispanic women are also at risk for developing osteoporosis (*National Osteoporosis Foundation: Risk factors*, 2006). Five percent of non-Hispanic black women aged 50 years and over are estimated to have osteoporosis with and additional 35 percent estimated to have low bone mass (*National Osteoporosis Foundation:*

Advocacy News and Updates, 2006). Ten percent of Hispanic women aged 50 years and older are estimated to have osteoporosis with an additional 49 percent estimated to have low bone mass.

In the 2003-2004 academic year, approximately 90 percent of NCAA Division III women cross country runners were white or Asian (Bray, 2005). Thus based on ethnicity, Division III female cross country runners in general seem to be from ethnic groups at increased risk for osteoporosis.

Body Structure and Weight

Petite and thin people have a greater risk of developing osteoporosis because they have less bone to lose than people with more body weight and larger frame sizes (*National Osteoporosis Foundation: Risk factors*, 2006). However, there has been some controversy over how thin, or what weight, is considered to be a risk factor for osteoporosis. A body weight of less than 70 kilograms, or 154 pounds, has been used as a predictor of low bone mineral density when using body weight alone as criterion for osteoporosis (Cadarette 2000; Cadarette 2001). In fact, a body weight of less than 70 kilograms has been shown to be the single best predictor of low bone mineral density.

The Osteoporosis Risk Assessment Instrument (ORAI) uses a weight of less than 60 kilograms (132 pounds) as a significant risk factor for osteoporosis with a weight of 60 to 70 kilograms (132 to 154 pounds) still being considered a risk factor for osteoporosis (Cadarette, 2000). The National Osteoporosis Foundation classifies those under 57.7 kilograms, or 127 pounds, as being at greater risk for osteoporosis (*National Osteoporosis Foundation: Risk factors*, 2006). In a study by Bensen et al. (2005), 57 kilograms, which coverts to 125.4 pounds, was used as the cutoff for being a risk factor for osteoporosis.

A low body mass index (BMI) is also considered a risk factor for osteoporosis. In a large data analysis of 60,000 men and women worldwide, the risk of hip fracture almost doubled in people with a BMI of 20 kg/m^2, compared with people with a BMI of 25 kg/m^2 (DeLaet, 2005). Bauer (2002) found that a BMI of less than 22 kg/m^2 could be expected to increase the risk of fracture. The Family Practice notebook.com website also uses a BMI of less than 22 kg/m^2 as a risk factor for osteoporosis (*Osteoporosis Evaluation*, 2000). A study by Frost, Blake, and Fogelman (2001) used a BMI of less than 20 kg/m^2 as a risk factor for osteoporosis.

Cross country is a lean sport with thinness and a low body weight being considered important. Thus, it seems likely that a number of female cross country runners would be at risk for osteoporosis based on their body weight and body size.

Menstrual History

Menstrual dysfunction, while a component of the "female athlete triad," is also a risk factor for osteoporosis. Menstrual dysfunction results in decreased levels of estrogen (Hobart & Smucker, 2000) which have a protective effect on bone (Lebrun, 2000).

Oligomenorrhea, one form of menstrual dysfunction, is the medical term for infrequent or light menstrual periods (Davidson, 2003). This is sometimes referred to as a cycle with intervals exceeding 35 days. Researchers have measured menstrual dysfunction in this way by having participants choose between the following responses: have not started menstruation, have not had a menstrual period for six months, have a menstrual period every six weeks, or have menstrual periods every 25 to 35 days (Henriksson, Schnell, & Hirschberg, 2000; Thompson & Gabriel, 2004). Another objective definition used to define oligomenorrhea is four to nine menstrual cycles per year (Burrows, Nevill, Bird, & Simpson, 2003; Hanekom & Kluyts, 2003).

Amenorrhea, a more severe form of menstrual dysfunction, is the medical term for cessation of the menstrual period (Turkington, 2004). There are two categories of amenorrhea, primary and secondary (Lebrun, 2000). Primary amenorrhea occurs when a female does not even start to menstruate. Any female who has not had her period by age 16 years should be evaluated for primary amenorrhea. Secondary amenorrhea occurs when periods that were previously regular become absent. Secondary amenorrhea has been defined as at absence of three or more consecutive menstrual cycles (Beals & Hill, 2006). Amenorrhea as defined by Hanekom and Kluyts (2003) was zero to three cycles per year. This was also the objective definition used by Burrows et al. (2003) and Harlan (1999).

Menstrual dysfunction and its negative affect on bone density have been reported by numerous studies. Gremion, Rizzoli, Slosman, Theintz, and Bonjour (2001) discovered that oligomenorrheic or amenorrheic women had significantly lower bone mineral density values than subjects that were eumenorrheic or oral contraceptive users. In a one year follow-up, the oligomenorrheic or amenorrheic women had a significant decrease in lumbar spine bone mineral density compared to the eumenorrheic or oral contraceptive users. Tomten, Falch, Birkeland, Hemmersbach, and Hostmar (1998) reported in their study that the group of runners with menstrual dysfunction had significantly lower bone mineral density on all measuring sites, which included total body, femoral neck, lumbar spine, lower leg, and arms, compared to the group of eumenorrheic runners. Galuska and Sowers (1999) found that for each year menarche was delayed bone density was lower at the lumbar spine and at the femoral neck. Thompson and Gabriel (2004) reported that amenorrhea, especially when combined with low calcium intake, can reduce bone mineral content. Reduced bone mineral content increases the risk of stress fractures and osteoporosis.

As stated previously when discussing the "female athlete triad" amenorrhea has been reported in 3.4 to 66 percent of female athletes, which is an incredibly large range, making it extremely difficult to determine how many athletes present this risk factor for osteoporosis (Hobart & Smucker, 2000).

Oral Contraceptives

One of the most influential factors affecting bone loss is estrogen. This is because estrogen stimulates calcium absorption allowing higher levels of calcium to be maintained in the blood (Calcium counseling resource, 2005). Since estrogen provides a protective factor against osteoporosis, it seems that oral contraceptives, which contain estrogen, would also help protect against osteoporosis. However, the effect of oral contraceptives on bone mineral density seems to be unclear.

A study by Almstedt Shoepe and Snow (2005) compared bone mineral density of young women with a history of oral contraceptive use to regularly menstruating controls. The study found that the regularly menstruating controls had significantly greater bone mineral density compared to the oral contraceptive users at the anterior-posterior and lateral spine, femoral neck, greater trochanter, total hip, and whole body. These researchers concluded that oral contraceptive use by young women may compromise bone health during a time when mineral is still accumulating. To further support this study, another study looking at oral contraceptive use in female endurance runners concluded that oral contraceptive use was associated with decreased bone mineral density of the spine and the femoral neck, and that early age at initiation of oral contraceptives may be an important risk factor for low peak bone mass in young women (Hartard et al., 2004).

A study by Prior et al. (2001) concluded in their study that population-based data show lower bone mineral density values for the trochanter and spine in premenopausal women who have used oral contraceptives compared with those who have never used oral contraceptives. This study also found that oral contraceptive users reported more alcohol and cigarette use than those who never used oral contraceptives.

A study by Strokosch, Friedman, Wu, and Kamin (2006) examined the effects of a triphasic oral contraceptive on adolescent females with anorexia. The study found that at the end of 6 cycles, there was a significant increase in lumbosacral spine bone mineral density in the oral contraceptive users; however, by the end of 13 cycles the effect on lumbosacral spine or hip bone mineral density in adolescent females with anorexia was not statistically significant. Grinspoon et al. (2003) in their study suggested that oral contraceptives (Ortho Tri-Cyclen) decreased bone turnover in osteopenic premenopausal women with hypothalamic amenorrhea. However, because this study evaluated the short term effects of oral contraceptives it could not be determined if estrogen could actually increase bone mineral density in this population.

Gambacciani, Monteleone, Ciaponi, Sacco, and Genazzani (2004) reported that oral contraceptive use in perimenopausal oligomenorrheic women has a bone-sparing effect. In an extensive review of literature on the effect of oral contraceptives on bone density Liu and Lebrun (2006) also concluded that there is good evidence for a positive effect of oral contraceptives on bone density in perimenopausal women. However, Liu and Lebrun also stated in their review of literature that there is limited evidence for a positive effect of oral contraceptives on bone density in healthy and anorexic premenopausal women.

Despite the limited research in this area, it is not uncommon for physicians to recommend estrogen replacement as treatment for athletes experiencing exercise-associated amenorrhea

(Cumming & Cumming, 2001). However, based on the evidence, it appears that more research is needed before it can be determined if significant gains in bone mineral density can be made by estrogen therapy.

Teegarden at al. (2005) found in their one-year study that dairy product intake at levels necessary to achieve the recommended intakes of calcium protected the total hip and spine bone mineral density from loss observed in young healthy women with low calcium intakes who were using oral contraceptives.

Dietary Practices

Good dietary practices have been shown to be beneficial in preventing osteoporosis, whereas poor dietary practices may contribute to lower bone mass density. Disordered eating, one an aspect of the "female athlete triad" is also a risk factor for osteoporosis. Disordered eating results in low energy availability which can be the result of reduced dietary energy intake, increased exercise energy expenditure, or a combination of the two (Sangenis, 2006). A study by Cobb et al. (2003) demonstrated the relationships between disordered eating and low bone mineral density. These researchers showed that disordered eating is associated with low bone mineral density, that disordered eating is associated with menstrual dysfunction, and that menstrual dysfunction is associated with low bone mineral density. Gibson, Mitchell, Harries, and Reeve (2004) revealed in their study that the effect of disordered eating to reduce bone mineral density could be explained by its association with menstrual dysfunction.

J. Harlan (personal communication, August 10, 2006), a head women's collegiate cross country coach for 11 years, stated that female college cross country runners typically run between 30 and 70 miles per week and may not consume enough calories to replace what they burn in their workouts. A study of 30 female distance runners reported that 93 percent of the athletes under consumed calories (Clark, 2001). Female cross country runners also suffer the highest number of eating disorders of any college athletes according to Busch (2007). Thus, it seems likely that a number of cross country runners on any given team may have dietary practices detrimental to their bones.

Calcium

The consumption of adequate amounts of calcium during adolescence and young adulthood is particularly important for females because it is positively associated with achieving peak bone mass (Anderson, 2004). Achieving peak bone mass may provide added protection against fractures and osteoporosis later in life.

Recommendations for calcium intake are provided in the Dietary Reference Intakes (DRIs) developed by the Institute of Medicine of the National Academy of Sciences (*Dietary supplement fact sheet: Calcium, 2005*). The DRI for calcium is listed as an Adequate Intake (AI), which is a level based on observations or experiments and determined by experts developing the DRIs to meet the needs of all individuals of a specific age and gender group (Yates, Schlicker, & Suitor, 1998). However, AIs are based on much less data and substantially more judgment than that used in establishing the Recommended Dietary Allowance (RDA). Nonetheless, both RDAs and AIs are used as goals for individuals. The current recommended daily AI for calcium is as follows: 210 mg for infants 0 to 6 months, 270 mg for infants 7 to 12 months, 500 mg for toddlers 1 to 3 years old, 800 mg for children 4 to 8 years old, 1,300 mg for males and females 9 to 18 years old, 1,000 mg for adults 19 to 50 years old, and 1,200 mg for adults over 50 years old (Food and Nutrition Board, 1997). The tolerable upper intake level (UL) for calcium is set at 2,500 mg for all ages.

Calcium functions as a "threshold nutrient" which means that below a certain level the effect of calcium on bone mass is limited by the amount of calcium available (Calcium counseling resource, 2005). Above the so called "threshold," increasing the amount of calcium does not permit additional gains in bone mass. In fact, once the body's calcium retention capacity is saturated, further increases in consumption of dietary calcium will result in increases in calcium excretion (Weaver & Heaney, 2006). The "optimal" amount of calcium to consume is that which would maximize genetically determined peak bone mass, maintain adult bone mass, and minimize bone loss later in life (Calcium counseling resource, 2005). For most people, consumption of the AI for calcium should support maximal retention of body calcium.

While consumption of adequate amounts of calcium are important in all periods of the life cycle, there are several periods in the female life cycle that calcium intake is critical. This is in prepuberty and adolescence, postmenopause, and during pregnancy and lactation (Anderson, 2004). In a study of adolescent girls, calcium intakes of 1,300mg or more each day were necessary for maximal calcium retention by the body's skeleton (Yates, Schlicker, & Suitor, 1998). For females between the ages of 11 and 24 years old the recommendation for calcium may be 1,200 mg to 1,500 mg, which is slightly higher than that recommended by the DRIs (Hobart & Smucker, 2000). For females in an estrogen deprived state, such as athletes experiencing menstrual dysfunction, 1,500 mg of calcium is recommended in an attempt to maintain calcium balance and help prevent osteoporosis (Committee on Sports Medicine and Fitness, 2000).

Despite adequate calcium being beneficial to bones, many Americans, including female collegiate athletes, fail to consume enough calcium to meet the daily calcium recommendations (Ervin, Wang, Wright, & Kennedy-Stephenson, 2004). Data from the National Health and

Nutrition Examination Survey, 1999-2000 (2006) for the United States Population showed the median calcium intake for females 12 to 19 years old was 661 mg and 684 mg for females 20 to 39 years old. The mean calcium intake was higher for these age groups at just below 800 mg. However, neither the median nor the mean met the DRI for calcium. It appears that when females enter the 12 to 19 years old age group, the median calcium consumption drops significantly. The significance of this finding is that at least 40 percent of the body's total skeletal mass is formed during the adolescent growth spurt which typically occurs within this age range (Calcium counseling resource, 2005).

The average calcium intake among female athletes appears to be inadequate and similar to that of the same aged individuals in the general population (Ward et al., 2004). A study of female adolescents in different sports showed the mean calcium intake of basketball players and dancers to be about 1,000 mg per day with skiers consuming a mean calcium intake of about 824 mg per day and a control group consuming approximately 769 mg per day. In a study across five women's collegiate athletic teams including basketball, golf, tennis, track/cross country, and volleyball, calcium intakes were below recommended levels, with a mean of 898 mg per day (Slawson et al., 2001). Female cross country runners consumed the lowest mean intake of calcium at 605 mg/day. Sarpolis (1999) reported that half of all runners and 40 percent of dancers and gymnasts do not get enough calcium. The most immediate risk for athletes not consuming enough calcium is stress fractures with a long term risk of osteoporosis.

A study of NCAA Division I female athletes participating in volleyball, cross country, soccer, cheerleading, track, or tennis showed that collegiate athletes consumed a mean of 2,058 mg of calcium while non-collegiate athletes consumed a mean of 1,512 mg of calcium (Thompson & Gabriel, 2004). Despite the high mean calcium consumption found in this study for both athletes and non-athletes, it found that 28 percent of those with irregular menstrual cycles reported consuming less than 1,500 mg of calcium per day and 23 percent of women in the 19 to 30 years old age group with normal menstrual cycles consumed less than 1,000 mg of calcium per day.

While assessing the calcium intake of female athletes is important for determining nutritional status and risk factors for stress fractures and future osteoporosis, methods for assessing a person's usual calcium intake are typically filled with errors. Diet recalls and diet records have errors in that they depend on the individual to accurately estimate portion sizes and recall or record all foods eaten. Errors also exist from the variability in food composition and from inadequacies of existing food composition tables (Weaver & Heaney, 2006). Hidden sources of calcium from fortified foods, water, and oral supplements including Tums or multi-mineral supplements may be overlooked. Conversely, dietary calcium tends to be over-reported (Thompson & Gabriel, 2004).

Supplements and Medications

Multivitamins and minerals and calcium supplements may be protective factors against osteoporosis by helping individuals meet the recommended amount of calcium. Winters-Stone and Snow (2004) found that one year of 1,000 milligrams of supplemental calcium helped prevent cortical bone loss in female distance runners. However, this study also found that 1,000 milligrams of supplemental calcium did not affect hip or spine bone mineral density.

Certain medications are risk factors for osteoporosis (*National Osteoporosis Foundation: Risk factors*, 2006). These medications include: glucocorticoids, excessive amounts of thyroid hormones, anticonvulsants, antacids containing aluminum, gonadotropin releasing hormones (GnRH) used for treatment of endometriosis, methotrexate for cancer treatments, cyclosporine A (an immunosuppressive drug), heparin, and cholestyramine (for controlling blood cholesterol levels). While it is not expected that college cross country runners would be taking any of these drugs, it would be important to note if they were when doing a nutrition assessment looking at risk factors for osteoporosis.

Exercise

While moderate physical activity has been shown to be beneficial in preventing osteoporosis, excess training may contribute to lower bone mass density by leading to menstrual dysfunction. Moderate physical activity can help increase bone mineral density by favoring bone mineralization and reducing the rate of bone loss (Quintas, Ortega, Lopez-Sobaler, Garrido, & Requejo, 2003). Weight-bearing and resistance training exercises are particularly associated with higher bone densities. Creighton, Morgan, Boardley, & Gunnar Brolinson (2001) reported that athletes involved in the greatest weight-bearing sports had higher bone mass density than those athletes involved in non-weight-bearing activities and sedentary individuals. A study by Risser et al. (1990) showed that female volleyball and basketball players had significantly higher bone density than swimmers and non-athletes.

Despite weight-bearing physical activity being beneficial in preventing osteoporosis, several studies have reported that female distance runners, despite the nature of their activity, do not possess comparably high bone mineral density (Burrows, Nevill, Bird, & Simpson, 2003; Winters-Stone & Snow, 2004). Decreased bone mineral density may therefore be an area of concern for female cross country runners.

Bone Mineral Density

Low bone mass puts athletes at an increased risk for stress fractures and also for future osteoporosis. Fredericson, Salamancha, and Beaulieu (2003) showed the relationship between low bone mass and stress fractures in a study that discovered 9 out of 12 female distance runners who experienced stress fractures were also experiencing either osteopenia or osteoporosis based on their T-score value. What is particularly frightening about decreased bone mass is that bone loss occurs without symptoms; therefore, it is impossible for people to know their bone status unless they have their bone mass density measured or after they have experienced a fracture as a result of weak bones.

There are a variety of ways to measure bone mineral density (BMD) that can help determine bone mass, including those that measure the hip, spine, wrist, finger, shin bone, heel, and total body. These tests that measure bone mineral density provide a T-score which is a measure of bone mineral density that compares an individual's BMD to an optimal BMD of a 30 year old healthy adult. It is currently accepted that the average age of peak bone mass is 30 years; however, Hobart and Smucker (2000) site various sources that say the average age of peak bone mass is closer to 18 to 25 years.

A T-score greater than -1.0 indicates normal bone density (*National Osteoporosis Foundation: Bone mineral density testing*, 2007). A T-score of -1.0 to -2.5 indicates that the person is considered to have osteopenia, and a T-score below -2.5 indicates osteoporosis.

Dual Energy X-ray Absorbptiometry (DEXA) is considered the "gold standard" of bone mineral density evaluation; however, this piece of equipment is also very expensive (Hanekom & Kluyts, 2003). The Hologic Sahara Clinical Bone Sonometer is a much cheaper piece of equipment used as a screening tool that measures bone mineral density by an ultrasound of the heel.

Preservation of bone mineral density is one of the many reasons to screen female athletes early for risk factors for osteoporosis. This may be especially true of cross country runners because a study of 30 female distance runners reported that 60 percent had low spinal bone loss (Clark, 2001).

Chapter III: Methodology

The purpose of this study was to investigate a Division III women's cross country team's risk factors for stress fractures and future osteoporosis. This chapter includes a description of how the subjects were selected, a description of the sample, and a description of the instruments used. The method for collecting the data and how the data was analyzed is also discussed. Lastly, limitations in the methodology are addressed.

Subject Selection and Description

Subjects for this study were selected from a National Collegiate Athletic Association (NCAA) Division III university women's cross country team. A team meeting was held in the fall of 2006 to explain this study and to ask the athletes for their consent to participate in this study. All of the athletes on the official cross country roster were asked to participate. Those members on the official cross country roster who could not attend the meeting were given an explanation of the study and asked to participate the next time they were available. Participation in this study was voluntary and subjects who chose to participate signed a consent form (see Appendix A). All 16 of the cross country runners on the official cross country roster consented to participate ranging in age from 18 to 23 years (M = 19.88, SD = 1.544).

Instrumentation

The researcher developed a nutrition assessment form (see Appendix B) that included all areas of the nutrition assessment to be addressed in this study. The nutrition assessment was aimed at identifying risk factors for osteoporosis in the cross country runners. To reflect the aim of this study, the form included a spot to record the following information: gender, age, ethnicity, menstrual cycle including age of menarche, number of cycles in the past year, and other description of menstrual cycle, medications including supplements and birth control, height, weight, body mass index (BMI), heel bone mineral density (BMD), and T-score.

A detailed 3-day food record form (see Appendix C) was used by the researcher to assess each subject's diet for average caloric intake and average calcium intake. The 3-day food record form included a spot for the subject's name, date, and days of the week the food record was done. There were also directions at the top of the sheet that reminded the subjects to be specific when recording the type and amount of foods and fluids consumed.

Height was measured using a Tanita body composition analyzer (model TBF-215) to the nearest 0.5 inch. Weight was measured using a Tanita body composition analyzer (model TBF-215) to the nearest 0.1 pound. The Tanita body composition analyzer (model TBF-215) also calculated body mass index. Heel bone mineral density and T-scores were measured using a Hologic Sahara Clinical Bone Sonometer.

Data Collection Procedures

A nutrition assessment aimed at identifying risk factors for stress fractures and future osteoporosis was performed on each subject in the fall of 2006. Each subject recorded a 3-day food record consisting of three consecutive days, including two week days and one weekend day, prior to setting up an appointment to be nutritionally assessed.

When the subject arrived at her individual appointment, the first step of the nutrition assessment was a personal interview in which several questions were asked to record on the nutrition assessment form. The subject was asked her name, age, and ethnicity. She was asked the age of menarche, the number of cycles she had this past year, as well as any other description of her menstrual cycle. Each subject was also asked if she was taking any medications, including oral contraceptives and dietary supplements, and if so, what they were. The subject was then asked for her 3-day food record in which the subject and the researcher went over together to clarify any questions about the type and amount of food consumed during the 3-day food record period. The researcher ensured that the subject's name was recorded on her 3-day food record to be able to match it to her nutrition assessment form and in case clarification was needed throughout the duration of the study. Once the baseline data was collected, the researcher began the physical part of the nutrition assessment.

Each athlete's height and weight was measured using a Tanita body composition analyzer (model TBF-215). Prior to each athlete stepping on the scale, the scale was sterilized with an alcohol pad. One pound of clothing was then entered in as a standard for each subject since each subject was wearing minimal clothing consisting of shorts and a T-shirt.

The next measurement was heel bone mass density which was measured using a Hologic Sahara Clinical Bone Sonometer. To be consistent, each athlete's right heel was measured. At least one half hour before this measurement was taken, the Hologic Sahara Clinical Bone Sonometer was turned on to warm up and after at least one half hour passed, a quality control check was done to ensure the machine was reading within normal limits. All data collected during the nutrition assessment was kept in a locked area in which only the researcher and researcher's advisor had access to.

Data Analysis

The Food Processor SQL Edition version 9.9 computer software program was used to analyze the 3-day food records. The Statistical Program for Social Sciences (SPSS) version 14.0 computer software program was used to analyze the data for risk factors for stress fractures and future osteoporosis. Descriptive statistics including mean, median, and standard deviation were conducted on the interval and ratio data. Pearson r correlation coefficients were computed to identify whether there was a relationship between age, height, weight, body mass index, heel bone mineral density, T-score, age of menarche, the number of cycles in the past year, average caloric intake, and average calcium intake

Limitations

A major limitation to this study was the small sample size (N = 16); thus, the statistics should be examined with caution. Another limitation to this study was that only one women's cross country team was asked to participate in this study. Therefore, the results may not be generalized to other populations. A third limitation is that each subject filled out her own 3-day food record, and subjects sometimes overestimate or underestimate foods eaten. Also, the questions the subjects were asked in the personal interview relied on the honesty and understanding of the subjects. There may also be limitations in the equipment used in the nutrition assessment. The Hologic Sahara Clinical Bone Sonometer used to measure bone mineral density is a noninvasive piece of equipment used as a screening tool for risk for osteoporosis. Due to the nature of running, heel bone mineral density may not accurately reflect total bone mineral density and thus risk for stress fractures and future osteoporosis. The Tanita body composition analyzer (model TBF-215) used was assumed to be calibrated as far as measuring height and weight accurately. This study also assumed that the nutrition assessment done was both valid and reliable in assessing risk factors for osteoporosis.

Chapter IV: Results

The purpose of this study was to investigate a Division III university women's cross country team's risk factors for stress fractures and future osteoporosis. This chapter discusses the outcomes of this study looking specifically at each of the risk factors assessed including gender, ethnicity, body structure and body weight, bone mineral density, menstrual cycle, average calcium intake, and medications including supplements and oral contraceptives. Table 1 summarizes the subject characteristics for the interval data collected.

Table 1

Summary of Subject Characteristics for Interval Data.

Characteristic	Mean	Median	Standard deviation
Age (years)	19.88	20.00	1.544
Height (inches)	65.00	65.00	1.683
Weight (pounds)	130.41	128.50	12.042
Body mass index (BMI)	21.66	21.50	1.656
Heel BMD (g/cm^2)	0.667	0.675	0.111
Heel BMD T-score	0.77	0.80	0.990
Age of menarche	13.94	14.00	0.998
# of cycles per year	9.31	12.00	3.666
Energy intake (kcals/day)	2,218	2,264	462
Calcium intake (mg/day)	1,094	1020	313

Age, Gender, and Ethnicity

All 16 subjects on the official Division III women's cross country roster at the university studied were asked to participate in this study and all 16 consented to participate. The subjects ranged in age from 18 to 23 years (M = 19.88 years, SD = 1.544). This study looked only at a women's cross country team; thus, all of the participants were female. In this study, 93.75% of the subjects reported that they were Caucasian. Only one participant was not Caucasian and she reported that she was Native American.

Body Structure and Body Weight

The subjects ranged in height from 62.5 inches to 68.5 inches with a mean and median of 65.00 inches (SD = 1.683). Their weights ranged from 117.2 pounds to 158.0 pounds with a mean of 130.41 pounds (SD = 12.042) and median of 128.50 pounds. The body mass index (BMI) for this cross country team ranged from 19.1 to 24.4 with a mean of 21.66 (SD = 1.656) and median of 21.50. By using the National Osteoporosis Foundation's cutoff value of less than 127 pounds as a risk factor for osteoporosis, 43.75 percent of the cross country runners in this study present low body weight as a risk factor for osteoporosis. By using a body weight of less than 154 pounds, which has been shown to be the single best predictor of low bone mineral density (Cadarette, 2000; Cadarette, 2001), 93.75 percent of this cross country team are at risk for low bone mineral density and thus osteoporosis. While 154 pounds has been shown to be the single best predictor of low bone mineral density, the National Osteoporosis Foundation cutoff of less than 127 pounds is a much more appropriate value to use for this population. Thus, less than 127 will be considered a risk factor for osteoporosis for female cross country runners in this study.

Using a body mass index (BMI) less than 20 kg/m^2 as a risk factor for osteoporosis, which has been used by Frost, Blake, and Fogelman (2001), 12.50 percent of the cross country runners in this study have a body mass index less than 20 kg/m^2 which puts them at increased risk for osteoporosis. When raising the body mass index cutoff to 22 kg/m^2, which has been used by Bauer (2002), 43.75 percent of the cross country runners may be at increased risk of osteoporotic fracture. And while BMI has been used in a few studies it is not as widely recognized as total weight thus total weight instead of BMI will be used as indicating risk for osteoporosis.

Bone Mineral Density

The women's cross country team's heel bone mineral density ranged from 0.510 g/cm^2 to 0.904 g/cm^2 with a mean of 0.667 (SD = 0.111) and median of 0.675. The team's heel bone mineral density T-score ranged from -0.6 to 2.9 with a mean of 0.77 (SD = 0.990) and median of 0.80. According to the National Osteoporosis Foundation, people with a bone mineral density T-score greater than -1.0 is considered to be "normal" and at low risk for fractures and osteoporosis. All of the cross country runners had a heel bone mineral density in this normal range. However, these results should be looked at with caution as the Dual Energy X-ray Absorptiometry (DEXA) is considered the "gold standard" for measuring bone mineral density and the Hologic Sahara Clinical Bone Sonometer is used primarily as a screening tool for bone mineral density. The DEXA is very expensive and that is why it was not available for this study. The Hologic Sahara Clinical Bone Sonometer was used instead since it is much cheaper and is also predictive of risk of osteoporotic fracture.

Menstrual Cycle

The subjects age of menarche ranged from 12 to 16 years with a mean of 13.94 years (SD = 0.998) and median of 14.00 years. Ten subjects, or 62.50 percent, began menstruating at age 14. With 93.75 percent of the subjects beginning menstruation before age 16 and one subject beginning menstruation at age 16 essentially none of the subjects would be classified as having primary amenorrhea according to Lebrun (2000) who classifies primary amenorrhea as any female who has not began menstruation by age 16.

The number of menstrual cycles subjects on this cross country team had in the past year ranged from and estimate of 2 to 3 menstrual cycles up to 12 menstrual cycles. The mean number of menstrual cycles was 9.31 (SD = 3.660) with a median of 12.00 menstrual cycles. Six subjects reported having less than nine menstrual cycles in the past year. However, two of the six subjects that reported less than nine menstrual cycles in the past year were taking an oral contraceptive designed to have them menstruate every three months. Thus by considering the two subjects taking oral contraceptives designed to have them menstruate every three months as being eumenorrheic, four subjects, or 25.00 percent, would be classified as having an irregular menstrual cycle defined by having less than 10 menstrual cycles in the past year.

It should be noted however that one of the two subjects taking an oral contraceptive designed to have her menstruate every three months stated that a normal menstrual cycle for her is every few months and that she goes on "the pill" to help her regulate her menstrual cycle. This subject also stated that she recently stopped taking oral contraceptives. Thus, based on the above descriptions of the subjects' menstrual cycles, perhaps five subjects should be classified as having an irregular menstrual cycle.

Four cross country runners reported taking an oral contraceptive in the past year. When taking these 4 cross country runners out of the statistics, 4 out of 12 cross country runners, or 33.33 percent, met the criteria for menstrual dysfunction. Three of the cross country runners not taking oral contraceptives had between four and nine menstrual cycles with one cross country runner having three or less menstrual cycles in the past year classifying them as oligomenorrheic and amenorrheic according to Burrows et al. (2003). Perhaps of importance is that one of the subjects that reported having less than nine menstrual cycles in the past year also reported that she recently started taking an oral contraceptive.

Energy Intake

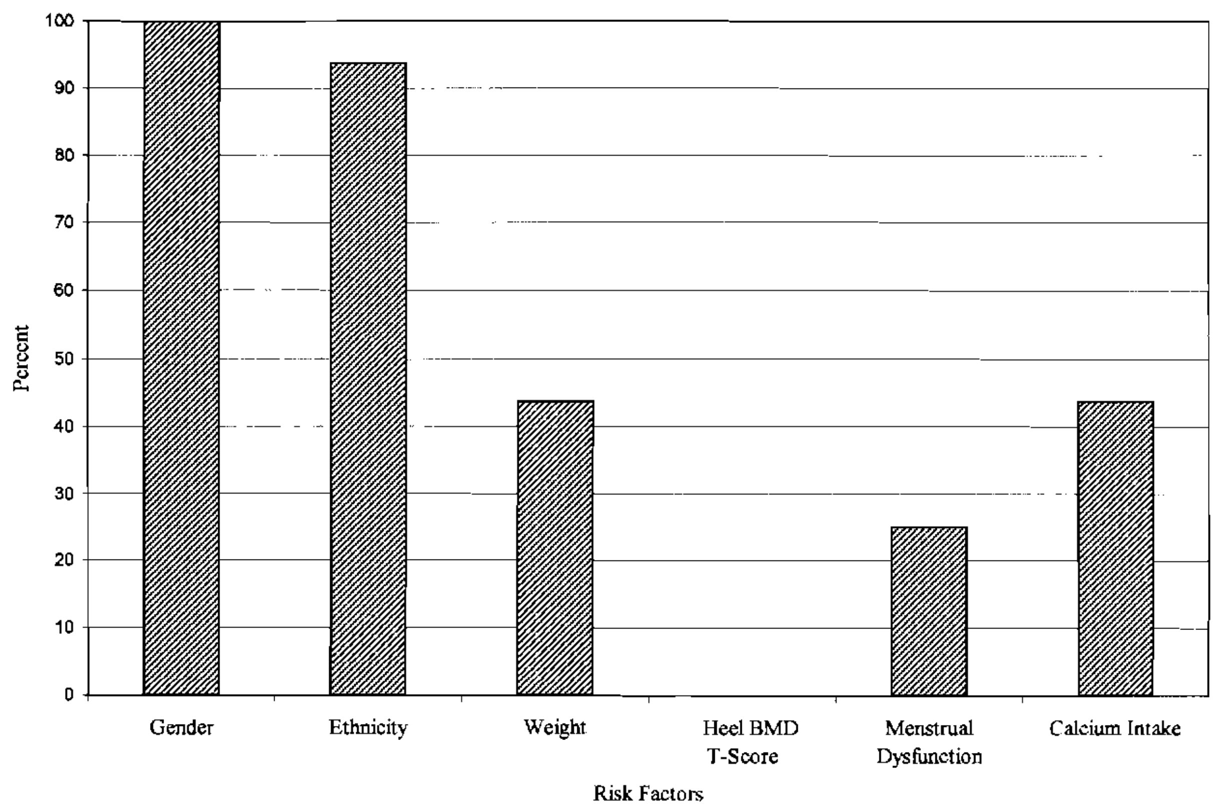
Energy needs and/or energy expenditure is somewhat difficult to quantify for the cross country team as a whole due to differences in metabolic rates and differences in training miles. Also, kilocalorie intake in and of itself is not used as an indicator of osteoporosis. However, kilocalorie intake can be used to identify possible causes for menstrual dysfunction and perhaps is a contributing factor to calcium intake as well. The kilocalorie intake for this cross country team ranged from an estimated 1,438 to 3,371 kilocalories per day with a mean of 2,218 kilocalories per day (SD = 462). In an attempt to interpret kilocalorie intake levels it was discovered that the four athletes classified as having menstrual dysfunction also had four of the six lowest kilocalorie intake levels on the team. Another interesting finding was that 3 of the 4 18 year olds on the team were in the top 4 for highest calorie intake.

Calcium Intake

The team's calcium intake from dietary sources ranged from 634 mg to 1,632 mg based on their 3-day food records. The mean calcium intake was 1,094 mg (SD = 313) with a median of 1,020 mg. Based on using the Adequate Intake (AI) for calcium intake of 1,300 mg for the 18 year olds and 1,000 mg for those subjects 19 and older (Food and Nutrition Board, 1997), 43.75 percent of the cross country did not meet the recommended amount of calcium. It is these values set by the Food and Nutrition Board that will be used to determine the cross country runners' risk for osteoporosis.

However, when using the recommended 1,500 mg of calcium for those with menstrual dysfunction (Committee on Sports Medicine and Fitness, 2000), the number of those not meeting the recommended amount of calcium from dietary sources rises to 56.25 percent. Figure 1 shows the percentage of cross country runners with risk factors for osteoporosis.

Figure 1: Percentage of Cross Country Runners with Risk Factors for Osteoporosis.



Medications and Supplements

None of the cross country runners reported taking medications that have been found to be risk factors for osteoporosis. Eighty one and a quarter percent of the cross country team reported taking a multivitamin and mineral supplement and/or a calcium supplement at least some of the time with 75.00 percent taking a multivitamin and mineral supplement and 18.75 percent taking a calcium supplement at least some of the time. The vitamins and minerals that the subjects received from supplements was not reported in the 3-day food records; thus the subjects taking a multivitamin and mineral and/or calcium supplement have a higher calcium intake than that reported under calcium intake which looked only at calcium intake from food sources.

Six cross country runners reported that they have taken an oral contraceptive at some point in their life. Five, or 31.25 percent, of the cross country runners reported that they were currently taking an oral contraceptive and four cross country runners, or 25.00 percent, reported that they took an oral contraceptive in the past year.

Correlations

A two-tailed Pearson r correlation was run on the interval data. A significant positive correlation, 0.679, $p < .01$, was found between age and heel bone density. A significant positive correlation, 0.587, $p < .05$ was also found between the number of menstrual cycles in the past year and total calcium intake. A significant negative correlation, -0.562, $p < .05$, was found between age and kilocalorie intake.

Chapter V: Discussion

This study explored a Division III university women's cross country team's risk factors for stress fractures and future osteoporosis. A nutrition assessment consisting of a 3-day food record and measurements of height, weight, and heel bone mineral density was conducted on each athlete. Each athlete was also asked several questions relating to factors that affect bone health. This chapter states the limitations to this study, draws conclusions from the results and compares this study's findings to other studies, and makes recommendations for future studies.

Limitations

A major limitation to this study was the small sample size (N = 16); thus, the statistics should be examined with caution. Another limitation to this study was that only one women's cross country team was asked to participate in this study. Therefore, the results may not be generalized to other populations. A third limitation is that each subject filled out her own 3-day food record, and subjects sometimes overestimate or underestimate foods eaten. Also, the questions the subjects were asked in the personal interview relied on the honesty and understanding of the subjects. There may also be limitations in the equipment used in the nutrition assessment. The Hologic Sahara Clinical Bone Sonometer used to measure bone mineral density is a noninvasive piece of equipment used as a screening tool for risk for osteoporosis. Due to the nature of running, heel bone mineral density may not accurately reflect total bone mineral density and thus risk for stress fractures and future osteoporosis. The Tanita body composition analyzer (model TBF-215) used was assumed to be calibrated as far as measuring height and weight accurately. This study also assumed that the nutrition assessment done was both valid and reliable in assessing risk factors for osteoporosis.

Discussion

Since this study looked only at a women's cross country team, all of the participants present gender as a risk factor for osteoporosis since being female is a risk factor for osteoporosis (*National Osteoporosis Foundation: Risk factors*, 2006). Over 90 percent of the subjects in this study were Caucasian which is not surprising as the Student Athlete Ethnicity Report for 2002-2003, reported that 87.8 percent of National Collegiate Athletic Association (NCAA) Division III women cross country runners were Caucasian (Bray, 2005). Thus, over 90 percent of the subjects in the cross country team studied are from an ethnic group at increased risk for osteoporosis.

The female collegiate cross country runners in this study had a mean weight of 130.4 pounds. Other studies examining female runners have found similar mean weights including studies by Cobb et al. (2003) and Burrows, Nevill, Bird, and Simpson (2003) who found mean weights of 128.7 pounds and 126.3 pounds respectively. When looking at weight as a risk factor for osteoporosis, the National Osteoporosis Foundation uses less than 127 pounds while Cadarette et al. (2000) found that a weight less than 154 pounds is the single best indicator of low bone mineral density when looking at weight alone. These two weight criteria give a large range, 43.75 percent to 93.75 percent, of female cross country runners in this study who present weight as a risk factor for osteoporosis. For female cross country runners, using the National Osteoporosis Foundation weight of less than 127 pounds is probably most appropriate.

Based on the heel bone mineral density T-score values it does not appear that any of the cross country runners on the team examined are currently experiencing osteopenia or osteoporosis. This study also found a significant positive correlation, 0.679, $p < .01$, between age and heel bone density suggesting that collegiate cross country runners are still building bone mass from age 18 to 23 years.

The age of menarche and the mean number of menstrual cycles per year discovered in this study were similar to that of other studies examining female runners. This study found the mean age of menarche to be 13.94 years (SD = 0.998) while Cobb et al. (2003), and Burrows, Nevill, Bird, and Simpson (2003) found the mean age of menarche to be 13.0 years and 14 years respectively. The mean number of menstrual cycles per year discovered in this study, 9.31, was also comparable to that of Cobb et al. (2003), and Burrows, Nevill, Bird, and Simpson (2003) who found 9.1 and 11 to be the mean number of menstrual cycles per year. When interpreting the number of menstrual cycles per year very literally, six subjects, or 37.50 percent, would be classified as having menstrual dysfunction. However, when considering the cross country runners taking oral contraceptives designed to have them menstruate every 3 months as being eumenorrheic only 4 of 16, or 25.00 percent, of the cross country runners met the criteria for menstrual dysfunction. This number falls within the percentage that Hobart and Smucker (2000) found, 3.4 to 66 percent, when doing an analysis of menstrual dysfunction in female athletes.

The team's mean calcium intake was 1,094 mg per day based on their 3-day food records. This is higher than that reported in a study by Slawson et al. (2001) who reported a mean calcium intake of 605 mg per day for collegiate cross country runners. The mean calcium intake for the cross country team studied was also higher than that reported by Burrows et al. (2003) who reported a mean calcium intake of 831 mg per day for female distance runners. However, the mean calcium intake was much lower than that reported for NCAA Division I female collegiate athletes participating in volleyball, cross country, soccer, cheerleading, track, or tennis who had a mean calcium intake of 2,059 mg.

Despite the mean calcium intake being 1,094 mg per day 43.75 percent of the cross country runners did not meet the Adequate Intake (AI) set by the Food and Nutrition Board (1997). When using the recommended 1,500 mg of calcium for those with menstrual dysfunction (Committee on Sports Medicine and Fitness, 2000), the number of those not meeting the recommended amount of calcium from dietary sources was 56.25 percent.

A large percentage of the cross country runners, 81.25 percent, took a multivitamin and mineral supplement and/or calcium supplement at least some of the time which could be a protective factor against osteoporosis by increasing calcium intake to the recommended level for those not consuming enough calcium from dietary sources. And while 25.00 percent of the cross country runners reported taking an oral contraceptive in the past year research is not conclusive on whether or not this is a protective factor for young women.

Conclusion

Based on this study, Division III female cross country runners exhibit several risk factors for osteoporosis with essentially all of the cross country runners being from a high risk gender and ethnicity group. Just over 40 percent of the cross country runners are at increased risk for stress fractures and osteoporosis based on their weight and dietary calcium intake. One fourth of the cross country runners experienced menstrual dysfunction in the past year which is a risk factor for stress fractures and osteoporosis. The good news was that all of the cross country runners currently have normal heel bone mineral density.

In conclusion, it appears that nutrition education in regards to bone health would be beneficial because early detection of risk factors can lead to early treatment which may aid in improving cross country runners' performances and health. Areas to focus on would be addressing the fact that menstrual dysfunction is not "normal" and in fact it is detrimental to bone health. When addressing menstrual dysfunction it would be important to address causes of menstrual dysfunction and possible ways to help correct it. Due to cross country runners' uncontrollable risk factors for osteoporosis perhaps adding some strength training to their exercise program would be beneficial for their bone health and maybe even their performance.

Recommendations for Future Studies

- Include a larger sample size with Division III cross country runners from multiple universities.
- Use the Dual Energy X-ray Absorptiometry (DEXA) to assess bone mineral density if funds permit.
- Since calcium intake is not the only nutrient that affects bone mineral density assess other nutrients related to bone density such as vitamin D, phosphorus, and magnesium.
- Assess dietary habits such as caffeine intake and alcohol intake.
- Assess whether or not getting calcium through a supplement has a positive effect on bone density.
- Explore oral contraceptives affect on young women's bones.
- Determine the nutrition attitudes of female cross country runners.

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Appendix A: Consent Form

Consent to Participate in UW-Stout Approved Research

Title: A nutrition assessment of female collegiate cross country runners

Description:
The goal of this study is to explore a National Collegiate Athletic Association Division III university women's cross country teams' health risks through a nutrition assessment. The nutrition assessment will consist of a 3-day food record, measurements of height, weight, and heel bone density, and a personal interview with the researcher asking several questions related to your nutritional status including age, ethnicity, menstrual cycle, and medications.

Risks and Benefits:
Participation in this study carries some risk. For example, you will be asked to provide information of a confidential nature regarding your menstrual cycle, medication use, alcohol intake, and dietary intake. Benefits to this study would include making you more aware of your current nutritional status which may assist you in making dietary and lifestyle changes to help improve both your performance and health. Benefits to this study also include the possibility of identifying nutritional risks in female cross country runners at a Division III university.

Time Commitment:
For this study, you will be asked to record everything that you eat for three consecutive days, including two week days and one weekend day. Once you have completed the 3-day food record you will be asked to set up an individual appointment with the researcher to complete the rest of the nutrition assessment. The nutrition assessment will be done on campus in Room 427 of the Home Economics Building. The actual assessment will take approximately 20 minutes. To thank you for your time, the researcher will gladly discuss the results of your nutrition assessment with you.

Confidentiality:
To ensure your data is kept confidential individual appointments for the nutrition assessment will be set up in which only you and the researcher will be in the lab. All the data collected during the nutrition assessment will be kept in a locked area in which only the researcher and researcher's advisor will have access. At the completion of this research all data that identifies individual participants will be shredded.

Right to Withdraw:
Your participation in this study is entirely voluntary. You may choose not to participate without any adverse consequences to you. Should you choose to participate and later wish to withdraw from the study, you may discontinue your participation at this time without incurring adverse consequences.

IRB Approval:
This study has been reviewed and approved by The University of Wisconsin-Stout's Institutional Review Board (IRB). The IRB has determined that this study meets the ethical obligations required by federal law and University policies. If you have questions or concerns regarding this study please contact the Investigator or Advisor. If you have any questions, concerns, or reports regarding your rights as a research subject, please contact the IRB Administrator.

Investigator: Laura Verdegan
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Statement of Consent:
By signing this consent form you agree to participate in this nutrition assessment of female collegiate cross country runners.

Signature______________________________________Date____________________

Appendix B: Nutrition Assessment Form

Nutrition Assessment Form

Name:	Date:
Gender:	Age:
Ethnicity:	
Menstrual Cycle: o Age of Menarche: o Number of Cycles in this Past Year: o Other Description of Menstrual Cycle:	
Medications: o Supplements: o Oral Contraceptive:	
3-Day Food Record: o Completed: Yes No o Subject's Name on 3-Day Food Record: Yes No o Researcher Clarified with Subject: Yes No	
Height (to the nearest 0.5 inch):	BMI:
Weight (to the nearest 0.1 pound):	Classification:
Heel Bone Density T-score: Heel Bone Density:	
Other Comments:	

Appendix C: 3-Day Food Record

This research has been approved by the UW-Stout IRB as required by the Code of Federal Regulations Title 45 Part 46.

Research Subject's Name____

Day 1 Date____________________ Day of the Week________________________

For this 3-day food record please record everything that you eat and drink for three consecutive days, including two week days and one weekend day. Eat as you normally would as this will help in doing a more accurate assessment of your diet.

Please record the time of day that you eat, the type and amount of food you eat, the type and amount of fluids you drink, as well as the seasonings and condiments you use. Be as specific as possible, noting brand name and/or how the food was prepared will help in the assessment process. Feel free to use the back of this page if you run out of room to write.

Time of Day	Food/Fluid	Amount	Notes
(Ex) 8:00 a.m.	Peaches n Cream Oatmeal	½ cup	instant

Comments

Research Subject's Name____

Day 2 Date______________________ Day of the Week__________________________

Please record the time of day that you eat, the type and amount of food you eat, the type and amount of fluids you drink, as well as the seasonings and condiments you use. Be as specific as possible, noting brand name and/or how the food was prepared will help in the assessment process. Feel free to use the back of this page if you run out of room to write.

Time of Day	Food/Fluid	Amount	Notes
(Ex) 8:00 a.m.	Peaches n Cream Oatmeal	½ cup	instant

Comments

Research Subject's Name____

Day 3 Date______________________ Day of the Week____________________________

Please record the time of day that you eat, the type and amount of food you eat, the type and amount of fluids you drink, as well as the seasonings and condiments you use. Be as specific as possible, noting brand name and/or how the food was prepared will help in the assessment process. Feel free to use the back of this page if you run out of room to write.

Time of Day	Food/Fluid	Amount	Notes
(Ex) 8:00 a.m.	Peaches n Cream Oatmeal	½ cup	instant

Comments