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The Inter-Relatedness of Nutrition, Menstrual Status, Lean Body Mass, and Injury Among High School Female Varsity Basketball Players

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ABSTRACT

Basketball is one of the highest risk sports for injury, especially for the female population. Studies have been performed looking at intrinsic and extrinsic factors that may contribute to an increased injury rate among female athletes. This study focused on nutrition, menstrual status, lean body weight and injury in female high school varsity basketball athletes (n=138). Nutritional and menstrual surveys were administered to these athletes. The athletes' body fat percentages were measured and calculated into lean body weight. Injuries were documented for one season. No clinically significant relationships were found among the variables. Descriptive data concerning nutrition, injury, menstrual status, and body composition are discussed. Data compiled revealed several problems among female high school varsity basketball athletes. The most notable of these data were the subjects' nutrition scores, which indicated less than 20 percent were receiving adequate nutrition based on the survey administered.

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DEFINITION OF TERMS

Acromion process- a flattened elevation found on the lateral most portion of the spine of the scapula

Aerobic capacity- the point at which oxygen consumption plateaus and no longer increases with an additional workload

Amenorrhea- a condition in which a female has not had a menstrual period in the last three or more consecutive months

Anatomical- in relation to structures and organs in the body

Anemia- the hematological state resulting from a decrease in the quantity or quality of red blood cells

Anterior cruciate ligament (ACL)- a ligamentous structure arises from the anterior superior portion of the tibia and extends posterior, laterally to the lateral condyle of the femur. The ACL prevents posterior displacement of the femur on the tibia and hyperextension of the knee joint

Anteversion- the angulation created in the transverse plane between the neck and shaft of the femur. The normal angle is between 15 – 20 degrees

Anthropometry- the science of measuring the human body for height, weight, and size of different parts. This includes measuring skinfolds

Basal Metabolic Rate- the minimal level of energy required to sustain the body's vital functions

Bioelectric impedance analysis- a method available to predict percent body fat using electrical impedance

Biomechanical alignment- the arrangement of body structures due to the action of external and internal forces on the living body

Blood Clotting- the process by which the blood is thickened and becomes a coagulum or jelly-like substance

Body Fat- all storage fat and sex specific fat found in the human body

Body Image- a person's own concept of physical appearance

Bulimia- a disorder characterized by recurrent episodes of binge eating during which the patient experiences a loss of control over eating and engages in either self-induced vomiting, use of laxatives and/or diuretics, or vigorous dieting and/or exercising

Caliper- an instrument with two hinged jaws used to measure the thickness or diameter of an object

Carbohydrate- a group of neutral organic chemicals including sugars, starches, and cellulose's

Cross-validation- the process of validating a test or statistical model by testing on a new group of subjects

Eating Disorder- a spectrum of diseases including anorexia nervosa, bulimia, and obesity

Energy Drain- a theoretical condition in which a female fails to menstruate because she fails to take in enough kilocalories to meet her body's demands for energy during exercise and during daily activities

Eumenorrhea- a normal menstrual period cycle of 22-35 days or 10-13 periods per year

Female Athlete Triad- the inter-relatedness of disordered eating, amenorrhea, and osteoporosis

Hydrodensitometry- a method use to predict body composition using under water weighing

Ideal Body Weight (IBW)- $$IBW = \frac{LBM}{1 - \frac{\text{desired \% body fat}}{100}}$$

Iron-Deficiency Anemia- a disorder in which the body's iron stores are completely depleted and hemoglobin concentration is low

Joint laxity- excessive movement within a joint

Lean Body Mass (LBM)- body mass minus the mass of storage fat; storage fat does not include essential fat found in bone marrow, CNS, or major organs

Menstrual Dysfunction- a disorder in which a female does not have a normal menstrual period cycle of 22-35 days or 10-13 menstrual periods per year. This disorder can be further classified as amenorrhea, oligomenorrhea, or polymenorrhea

Morbidity- an illness or an abnormal condition or quality

Mortality- the condition of being subject to death

Musculoskeletal alignment- the arrangement of muscle and bones within the body

Near-infrared spectrophotometry- a method used to predict body composition using fiber optics & the principles of light absorption and reflection

Nerve Transmission- the passage of electrical impulses along nervous tissue

Olecranon process- proximal most protrusion on the ulna which articulates with the olecranon fossa found on the distal portion of the humerus

Oligomenorrhea- a condition in which a female has a menstrual cycle length of 35-90 days or has less than 10 menstrual periods per year, but has had a menstrual period in the last 3 months

Post-Pubescent- the time period of life after puberty has been reached

Osteoporosis- a decrease in bone tissue mass per unit volume, causing skeletal weakness, even though the bone's morphology remains unchanged

Power- expressed in Watts (Work/Time); rate at which energy is expended

Prediction Equation- a mathematical calculation designed to determine percent body fat

Q angle – the angle formed between the line of pull of the quadriceps muscle and the patellar tendon

Scapula- commonly referred to as the shoulder blade. One of the pair of large, flat, three-sided bones that forms the back of the shoulder

Scoliosis- an abnormal curvature of the spine

Skinfold measurement- a method used to predict percent body fat using a caliper to measure skinfold thickness at designated areas

Stress Fracture- a microscopic breakage of bone resulting from repeated loading with relatively low magnitude forces

Subclinical Anorexia- a disorder in which an athlete has symptoms of an eating disorder but does not meet DSM-IV criteria for anorexia nervosa or bulimia nervosa. This is sometimes referred to as anorexia athletica.

Subcutaneous- beneath the skin

Subscapular- region of body directly inferior to the scapula

Torque- a twisting force

Triceps- a large muscle that runs along the entire length of the back of the upper arm. It extends the forearm

Ulna- a long bone found in the forearm, articulates with the distal end of the humerus and proximal and distal end of the radius

Varus- an abnormal position in which a part of a limb is turned inward toward the midline

Weight-bearing Activities- an event that involves loading weight through any or all of the extremities

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

Figure | Page

LIST OF APPENDICES

CHAPTER 1
INTRODUCTION

Background to problem

Florence Griffith Joyner, Janet Evans, Steffi Graf, Oksana Baul, Keri Strug, Sheryl Swoopes, the list goes on. What do these women have in common? Each female athlete has dominated her sport and brought it to an increased level of intensity and recognition. Their pictures cover television and milk advertisements. They are the guest stars of Oprah Winfrey, Jenny Jones and more. However, a behind the scenes look at these stars may reveal a different story than the fame and glory.

These women have pushed their bodies to the maximum level of performance, and all started training while they were very young. Many of today's young athletes are striving to be the next Flo Jo or the next Keri Strug. What many of them do not realize, however, is that not all female bodies were designed to be pushed that far.

Since Title IX was added to the Education Amendment in 1972, women's participation in sports has increased dramatically, by 600%, compared to a 20% increase in men's participation for the same time period (Nattiv, Arendt, Riehl, 1996). With this increased participation has come an entirely new realm of problems that are specific to the female athlete. Female sport injuries now constitute a larger portion of total sport injuries when compared to men (Nattiv et al., 1996; Hutchinson & Lloyd-Ireland, 1995; DeHaven & Linter, 1986).

Researchers have proposed numerous reasons for the increased rate of injury among females. Differences among males and females can be found in relationship to strength, body fat, aerobic capacity, power, speed, biomechanical alignment, and joint laxity (Nattiv et al., 1996; Beim & Stone, 1995; Lloyd, 1993). Females also have several unique attributes, such as menstrual concerns and a high prevalence of eating disorders, which can contribute to injury when disturbances among these attributes occur. Two problems that have received much publicity recently are the prevalence of menstrual dysfunction and eating disorders among female athletes. The prevalence of these disorders has become so well publicized that, together with decreased bone density, it has been termed the female athlete triad (Benardot, 1996; Nattiv et al., 1996; Beim & Stone, 1995; Lloyd, 1993; Yeager, Agostini, Nattiv, & Drinkwater, 1993). The triad postulates that the increased rate of eating disorders among female athletes leads to menstrual dysfunction. In turn, the menstrual dysfunction causes decreased bone density due to a decreased amount of estrogen production. This decreased amount of estrogen may lead to premature osteoporosis. (Fig. 1.1) (Benardot, 1996; Nattiv et al., 1996; Beim & Stone, 1995).

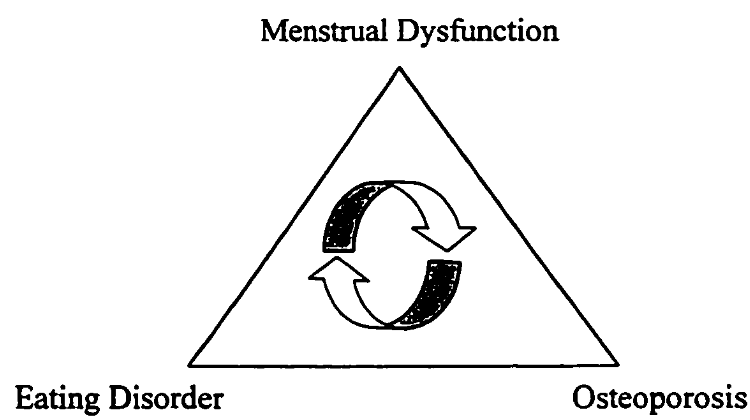

Figure 1.1 Female Athlete Triad

Nutrition has been shown to play a role in eating and menstrual disorders (Benardot, 1996; Nattiv et al., 1996; Rock, Gorenflo, Drewnowski, & Demitrack, 1996; Beim & Stone, 1995; Lloyd, 1993; Whitney, Calaldo & Rolfes, 1991). Poor nutrition also contributes to lean body weight changes. As the body becomes undernourished, lean body weight begins to decline. These changes in menstrual, nutritional, and lean body weight status may predispose an athlete to injury.

Nutritional deficits are the result of an imbalance between nutrient supply and demand of the body. This happens when the body's requirement for a particular nutrient is not met, due to either inadequate intake or excessive utilization by the body (Berkow & Fletcher, 1992). As a result, the demand for energy to support physical activity and growth is not met and often leads to an individual being underweight. Being underweight becomes especially hazardous when it is accompanied by malnourishment. An inadequate supply of vitamins, minerals, and energy sources leaves the body at a disadvantage to handle the physical requirements of sport and exercise (Whitney et al., 1991).

Past research has shown that diet and menstrual status have an effect on injury rate among female runners and gymnasts. Although the relationship is known to exist, it is still poorly understood (Benardot, 1996; Beim & Stone, 1995; Lloyd et al. 1986). Research has shown that the incidence of eating disorders, which can lead to malnourishment, is increased in sports where there is a focus on the athlete's body fat percentage or weight. These sports include gymnastics, ballet and dance, figure skating, long distance running, and male wrestling (DuRant, Pendergrast, Seymore, Gaillard, & Donner, 1992; DeHaven & Linter, 1986; Lloyd et al., 1986). Although basketball is not such a sport, eating disorders and menstrual dysfunction have been shown to be present in the general female adolescent population; (Mansfield & Emans, 1989; Nattiv et al., 1996; Timmerman, 1996) therefore, female basketball athletes require further research in this area.

Interestingly, basketball has the greatest difference in injury rate between males and females. Females have been reported to injure their anterior cruciate ligaments (ACL) at a rate of 7.8 times more than their male counterparts (Huston & Wojtys, 1996). Research has listed many possible predisposing factors, which will be discussed later, that may contribute to this imbalance. However, no single factor or specific combination of factors has been identified as the cause of the increased rate of ACL injury among females. Also, no research, to our knowledge, has studied the relationship between nutrition, menstrual status, and lean body weight as risk factors for ACL and other injuries among high school female basketball athletes.

Further research is needed to identify causes of problems specific to the female athlete. To date, sport related research has been primarily male oriented. Since female athletes require special attention in several areas including psychological, nutritional, gynecological, and orthopedic, research focused on the female athlete is needed.

Therefore, the results of our research will benefit the health care worker, the coach, and the athlete in providing the knowledge to prevent and treat injuries. For example, if a therapist/trainer is treating an injured female athlete who also has nutritional inadequacies, her recovery time may be prolonged if this is not corrected. This nutritional deficiency may also have been a predisposing factor to the injury and, therefore, may be prevented if athletes are properly educated in the future. Since the overall injury rate, as well as ACL injuries among female basketball players is prevalent, physical therapists treat these athletes on a daily basis. If the contributing factors to these injuries can be identified, physical therapists will have a greater understanding of how to treat the existing problems and how to prevent future injuries from occurring.

Problem Statement

Little research has been done to study the relationship between lean body weight, nutritional status, menstrual dysfunction, and injury rate in high school female basketball players. If it can be proven that nutritional deficits and menstrual dysfunction show a relationship with increased injury among this population, health care workers, athletes, and coaches will have a better understanding of how to prevent and treat these injuries.

Purpose

The purpose of this descriptive, relational, prospective research study is to examine if there is a significant relationship among nutritional status, menstrual status, lean body weight, and injury occurrence (during one season) in female high school varsity basketball players. It is also the purpose of this research to provide descriptive data concerning the percentage of female high school varsity basketball players who are considered to have inadequate nutrition and/or who have low lean body weight. Descriptive data concerning the prevalence of menstrual dysfunction among the basketball players will also be provided.

Hypotheses

Our null hypotheses are (1) The eumenorrheic status of female high school varsity basketball players will not show a significant relationship ($p<.05$) with injury occurrence during one basketball season. (2) A total score of 54 or less (inadequate nutrition) on the food frequency questionnaire completed by a female varsity basketball player will not show a significant relationship ($p<.05$) with that athlete's injury occurrence during one basketball season.

CHAPTER 2
LITERATURE REVIEW

Historical Background on Women's Athletics

Over the past century the female's presence in the world of athletics has grown dramatically and is now established throughout the world. At the beginning of the century when the modern Olympic games were founded, women were excluded from participation because women's sports were considered to be "against the laws of nature" (Nattiv et al., 1996).

A pivotal point in the history of American women's participation in sport and exercise was in 1972 when Title IX of the Educational Assistance Act was passed. Since then there has been a huge increase in female sport participation. Title IX states "no person in the U.S. shall, on the basis of sex, be excluded from participation in, be denied the benefits of, or be subject to discrimination under any educational program of action receiving federal financial assistance" (Nattiv et al., 1996, p.841). After Title IX, a 600% increase was seen in women's athletic participation compared to a 20% increase in men's athletics during the same time period (Nattiv et al., 1996).

This review of literature will cover the following: (1) injury incidence of female athletes, focusing on knee injuries; (2) nutritional concerns in athletics; (3) the appropriate amount of lean body weight; (4) menstrual function and how it relates to bone health and injury; and (5) a discussion of methods to measure lean body weight and the method chosen for this study.

Injury Incidence

With the increase in women's participation in sport that occurred with the passage of Title IX came an increased injury incidence among female athletes (Beim & Stone, 1995; DeHaven & Linter, 1986). It was common, even 10 years ago, for a female athlete to receive different treatment than a male with an identical injury. For example, women runners who complained of tendonitis were often told to stop running, whereas men were given a specific treatment protocol that combined rest with continuous activity. This is no longer common. It is no longer predominately male athletes who are receiving rehabilitation. Women athletes are being rehabilitated as frequently as male athletes. There has been some suggestion that women are more susceptible to athletic injury than males (Lutter, 1993), but most of the current literature states that injury patterns are more sport-specific than sex-specific. However, there are several types of injuries which seem to be more prevalent in the female athlete.

One injury of increasing concern is the extremely high occurrence of anterior cruciate ligament (ACL) injury among females when compared to males (Nattiv et al., 1996; Squire, 1993). Other injuries which are found to be more prevalent among female athletes include: patellar subluxation/dislocation, low back problems such as spondylosis & spondylolithesis, bunions, stress fractures, and patellofemoral pain syndrome (Nattiv et al., 1996; Beim & Stone, 1995; Sickles & Lombardo, 1993; DeHaven & Linter, 1986). The reason for this high frequency of injuries in the female is uncertain and has not received equal attention when compared to research on male athletic injuries (Beim & Stone 1995; Clark, 1993).

Possible Contributing Factors

There are many possible predisposing factors to this frequency of ACL injuries. Nutritional disorders are more common to the female athlete than to the male athlete. Menstrual dysfunction is both prevalent in and specific to females (Timmerman, 1996; Barnett & Wright, 1994; Arendt, 1993; Clark, 1993; Economos, Bortz, & Nelson, 1993; Johnson, 1994; Lloyd, 1993; Sanborn, Albrecht, & Wagner, 1987; Loucks & Horvath, 1985; Brooks, Sanborn, & Albrecht, 1984). These can cause numerous changes within an athlete's body and will be discussed more thoroughly in this chapter.

Other predisposing factors may include post-pubescent changes. Post-pubescent females show a relative increase in body fat while boys show a relative increase in muscle weight. This is reflected by a relative decrease in muscle strength, power, and speed in women when compared to men (Nattiv et al., 1996). Female's hips broaden relative to their shoulders and waist, whereas male's shoulders broaden relative to their hips. The wider pelvis in females can produce varus alignment at the hips and increased femoral anteversion resulting in an increased Q angle (the average for women is 13.6° and 17.0° for men) (Beim & Stone, 1995). Absolute upper extremity muscle strength in women is 40-75% of men; lower body muscle strength is 60-80% compared to men. Women have the same capacity for strength gains, but do not experience the same degree of muscle hypertrophy as men, due to lower testosterone levels (Squire, 1993). Other studies have stated young women were not conditioned properly in specific skills for their sports. This improper conditioning may possibly result in more prevalent injuries (Nattiv et al., 1996).

One study, conducted by Zelisko, Noble, & Porter (1982), compared injuries sustained by male and female professional basketball players. The frequency of injury in women was 1.6 times greater than that of men, with women sustaining 60% more injuries. A significant difference was also seen in the frequency of sprains in women. These authors, as well as others, suggest that this increase in sprains indicates the need for greater emphasis on conditioning (Huston & Wojtys, 1996; Beim & Stone, 1995; Woodford-Rogers, Cyphert, & Deneger, 1994; Hoogenboom, 1993).

Conditioning for strength and power is important in the prevention of injury since muscle can lend dynamic stability to the passive protection provided by ligamentous structures. Huston & Wojtys (1996) suggest this may be true in the high or middle school levels, but training and conditioning programs after these levels--in the NCAA and professional leagues--are so very sophisticated and elite that conditioning is probably not an issue. They suggest if women are substantially different physiologically than their male counterparts, increased conditioning programs may not be the answer, and further research needs to be done to address the physiological issues.

The focus of this study is on the female adolescent basketball athlete. The popularity of basketball has grown tremendously over the past decade, especially among adolescents. In fact, participation in competitive basketball among females has quadrupled over the last 15 years (Lazarus, 1997). Even though basketball is not a contact sport, such as football, these players are in a high risk category for non-contact injury. A contact injury is due to a person colliding with some object or another player, whereas a non-contact injury, often seen in basketball, does not involve this impact. Among the highest injury risk sports are football, gymnastics, wrestling, and basketball (DuRant, Pendergrast, Seymore, Gaillard, & Donner, 1992; DeHaven & Linter, 1986).

"Although basketball is predominantly considered a limited contact sport, trauma from collisions and falls and the tremendous stresses placed on the body from the sudden acceleration, deceleration, pivoting, and explosive movements involved in this sport place athletes at significant risk for acute injuries" (Sickles & Lombardo, 1993, p.207). In addition, overuse injuries are very common due to the repetitive running, jumping, and landing demanded in this sport.

Knee Injuries

DuRant et al. (1992) investigated 674 high school athletes ranging in ages from 13-20 years. Results revealed the percentage of female basketball players who experienced athletic injuries (33.3%) was similar to that of male football players (36.3%). Among the athletes, the knee was the most frequently injured body part followed by the ankle (DuRant et al., 1992; DeHaven & Linter, 1986). Injuries sustained by female players are more often major injuries (Squire, 1993). Other studies have shown the ankle to account for the majority of adolescent basketball injuries, while the knee is the second most commonly injured joint (Sickles & Lombardo, 1993; Zelisko et al., 1982). Haycock and Gillette (1976) conducted three independent surveys that targeted female student athletes. Results from this study also confirmed that basketball had the highest frequency as well as greatest variety and severity of injuries (Zelisko et al., 1982). Epidemiological data are limited for adolescent basketball players, but most studies suggest female basketball players are at a greater risk for injury than their male counterparts (Sickles & Lombardo, 1993). Therefore, more research in the area of the adolescent basketball player is needed.

The significant number of knee injuries among female basketball players has been published repeatedly (Huston & Wojtys, 1996; Cook & Leit, 1995; Hutchinson & Lloyd-Ireland, 1995; Woodford-Rogers et al., 1994; Emerson, 1993; Sickles & Lombardo, 1993; Beckett, Weightie, Browers, & Stoll, 1992; DeHaven & Linter, 1986; Zelisko et al., 1982.). Eighty-nine percent of all surgeries performed on female basketball players in one year were on injured knees (Emerson, 1993). In fact, many studies show the most prevalent knee injury among female players is a torn ACL (Huston & Wojtys, 1996; Nattiv et al., 1996; Hutchinson & Lloyd-Ireland, 1995; Woodford-Rogers et al., 1994; Emerson, 1993; Beckett et al., 1992).

ACL injuries

The ACL prevents anterior tibial translation on the femur and hyperextension of the knee joint. Normally when the knee is flexed at a 90° angle, the tibia cannot be pulled anteriorly because it is held by the ACL (Moore, 1992). Approximately 50,000 surgeries are performed each year to repair male and female ruptured ACL's (Emerson, 1993). Many of these surgeries are likely performed on females because many studies have shown that females require surgery after an ACL injury three times more often than males (Squire, 1993). A 1989-90 NCAA injury survey reported female athletes injured their ACL's at a rate of 7.8 times more than males (Huston & Wojtys, 1996). Other studies show a 6.1, 8, and 10 times greater ACL injury occurrence in high school, college, and professional female basketball players, respectively, when compared to their male counterparts (Hutchinson & Lloyd-Ireland, 1995; Emerson, 1993). ACL injuries account for 25% of all female basketball injuries; and 23 out of 24 ruptures are due to a non-contact mechanism of injury (Sakai, Tanaka, Kurosawa, & Masujima, 1992). This non-contact mechanism of injury occurs most commonly in deceleration and change of direction, when the tibia is externally or internally rotated with or without hyperextension. Basketball arguably may present the greatest risk of ACL injury due to the mechanical phenomena which occur repetitively in the game such as running, jumping, rapid pivoting, and sudden acceleration and deceleration on the court (Emerson, 1993).

To this date, many studies have been done on ACL injuries, but no specific conclusions have been reached on the physiological causal relationship. However, it is known that there are many proposed predisposing intrinsic and extrinsic factors leading to ACL injury. The intrinsic factors include a narrow intercondylar notch, deficient hamstrings in relation to quadriceps, muscle recruitment order, muscle reaction time, enlarged tibial eminences, increased femoral anteversion, excessive knee joint laxity, knee hyperextension, increased Q angle, excessive subtalar pronation, and weak vastus medialis obliquus. Extrinsic factors may include training errors, such as a sudden increase in training intensity; hard playing surfaces; improper footwear; body weight; and fitness level-fatigue while exercising (Nattiv et al., 1996; Hutchinson & Ireland, 1995; Emerson 1993; Squire, 1993; Sakai et al., 1992; Woodford-Rogers et al., 1992; Beckett et al., 1992; Souryal, Moore, & Evans, 1988).

Studies of ligament failure have shown that ligaments acting alone would never be able to withstand the levels of loading during athletic activity, which places more than 5 times one's body weight across the knee joint. It is the dynamic muscle stabilization that protects the knee joint from such stress and strain. Passive knee structures, such as ligaments and menisci, play a role in functional stability of the knee. However, this role is small when compared to the stabilization provided by the quadriceps, hamstrings, and gastrocnemius muscles in the leg. Balance between the quadriceps and hamstring power is important to knee function because the quadriceps can produce forces in excess of those needed for ligamentous failure. Huston and Wojtys (1996) reported Division I female athletes relied more on the quadriceps and gastrocnemius muscles to resist anterior tibial translation, whereas male athletes recruited the hamstring muscles more frequently for initial knee stabilization. Female athletes also required a statistically significant ($p<0.05$) longer amount of time (430 msec) to produce hamstring peak torque during isokinetic testing than male athletes (328 msec). Knee laxity was also significantly ($p<0.05$) greater in the female athlete (4.5mm) compared to male athletes (3.5mm). Furthermore, Huston and Wojtys reported considerably weaker knee extension and flexion in female athletes compared to male athletes, even when normalized for body weight. This demonstrated statistical significance ($p<0.05$) at 60 deg/sec. It is possible that all or none of these findings could play a role in the abundant number of ACL injuries in the female athlete. However, it is necessary to continue research in this area in an attempt to find causal factors to this problem. Only then can appropriate prevention strategies be applied.

Nutrition

Could improper nutrition and menstrual dysfunction be playing a role in female athletic injury as well? These factors tend to be overlooked in a sport such as basketball, yet nutritional intake plays an important role in the performance and health of an athlete. Since athletes are constantly seeking to optimize their performance, they may be at risk for following diet fads or misleading information found in the media. New information regarding what creates the super athlete appears daily and is advocated and refuted just as often. There are, however, several guidelines for the nutritional intake of an athlete, such as total necessary kilocalories and specific sources of these kilocalories, which have been substantiated by previous research and remain substantiated currently. These guidelines must then be individualized to the athlete. (Nattiv et al., 1996)

Each athlete has specific energy needs. The body can adapt to athletic training and can become more efficient at burning kilocalories and using oxygen with time. "Efficiency of energy burned refers to the quantity of energy required to perform a particular task in relation to the actual work accomplished" (Cummings & Rewinski, 1996, p.869). According to Cummings & Rewinski (1996), there are several factors that determine how much energy an athlete will require. These factors include: (1) body composition, (2) sex, (3) energy expenditure for training, competition, and daily activities, and (4) whether an athlete is gaining or losing body weight.

The first factor, body composition, determines a person's basal metabolic rate (BMR) (Cummings & Rewinski, 1996). BMR is the minimal level of energy required to sustain the body's vital functions (McArdle, F.L. Katch, & V.L. Katch, 1991). Different body tissues have unique metabolic rates that are specific to tissue type. For example, fat is metabolically less active than muscle (McArdle et al., 1991). Since post-pubescent females generally possess more body fat than men of similar size, females on average have a 5-10% lower BMR than men. The gender difference between BMR's can be eliminated when the metabolic rate is expressed per unit of lean body weight (McArdle et al., 1991). Lean body weight is the amount of total body weight that is fat free. This lean body weight is responsible for burning approximately 75% of all kilocalories (McArdle et al., 1991). Athletes usually have a higher lean body weight. Since muscle is more metabolically active than fat, athletes tend to have a 5% higher BMR than non-athletic individuals. This necessitates a higher caloric intake for athletes in order to meet their energy demands. Female athletes will require slightly lower caloric intakes than male athletes due to females having a lower BMR (Cummings & Rewinski, 1996).

Energy requirements are also sport specific. As the intensity of the sport increases, more kilocalories per minute are burned. Within each sport, there are also varying levels of intensity. For example, if a 125 lb. athlete plays 32 minutes of half-court basketball, he or she will burn approximately 122 kilocalories. If the same athlete plays 32 minutes of vigorous competition basketball, he/she will expend approximately 262 kilocalories (Cummings & Rewinski, 1996).

Energy Source

The kilocalories needed for any sport need to be acquired through ingesting food. Foods classified as carbohydrates are the body's main source of energy. However, the body can only store a limited amount of carbohydrates. The majority of carbohydrates are stored in the liver or in the muscles as glycogen. The liver's supply of glycogen is used to maintain blood glucose levels. The glycogen in the muscle is used when the muscle requires energy (Cummings & Rewinski, 1996). Glycogen stores in muscle are extremely important in exercise (Whitney, Cataldo, & Rolfes, 1991). An athlete's ability to delay fatigue and enhance endurance relies primarily on the amount of glycogen he/she has stored in the muscle. The body uses this glycogen to fuel the activity; and when the stores are depleted, muscle fatigue occurs (Whitney et al., 1991; Cummings & Rewinski, 1996).

Muscle glycogen is used 18 times faster when an athlete is exercising anaerobically than when he/she is training aerobically (Cummings & Rewinski, 1996). Since basketball is both an aerobic and anaerobic sport, the athlete must have an ample supply of glycogen stored to counteract the more rapid rate of glycogen breakdown (Whitney et al., 1991; Cummings & Rewinski, 1996). In a study of preadolescents enrolled in a basketball program, Gutgesell (1991) found that 40.7% of all injuries occurring in one season, were acquired during the fourth quarter. Slightly over seventy percent occurred during the second half. Gutgesell hypothesized that this was related to the athlete's fatigue level late in the game. Although this study was done on preadolescents, the implications of a relationship between fatigue and injury may also apply to the high school athlete. Emerson (1993) also states in an article entitled *Basketball knee injuries and the ACL*, that "exercise and fatigue produce glycolytic changes rendering loss of strength and contributing to ACL injury" (p.319). Research that correlates fatigue with injury in high school female basketball players is lacking. If fatigue does have a contributing role in the injury of athletes, the role of nutrition in the health of an athlete may be severely underestimated since inadequate nutrition can cause fatigue.

Caloric Requirements

It has been estimated that a highly active adolescent male during a growth spurt may require more than 4,000 kilocalories a day simply to remain at his current weight (Whitney et al., 1991). Economos, Bartz, & Nelson (1993) recommend an energy intake of 1800-2200 kcal per day for non-exercising females and 2,600-3,300 kcal daily for exercising females. One limitation of this study, however, is that no age groups for these recommendations were given. In one study, female runners, training between 9.3 and

12.8 hrs/wk, were found to have consumed only between 1,874.8 - 2,022.4 kcal/day, well below the recommended intake. The authors of this study also noted that since these recommended intakes were designed for exercising females, the energy intake needed for females intensely training for competition may actually be higher (Perry et al., 1996). This high demand for energy may predispose adolescents to becoming underweight (Whitney et al., 1991). When adolescents become underweight or do not ingest enough kilocalories for their energy needs, they put themselves at risk for malnutrition (Perry et al., 1996).

Krebs-Smith et al. (1996) found that intakes of fruits and vegetables increased in adolescent boys as their demand for energy increased with age. Although adolescent girls require less energy than adolescent boys, they still require more energy than younger girls. Unfortunately, the adolescent girls were not found to be increasing their intakes of fruits and vegetables with age as were the adolescent boys (Krebs-Smith et al., 1996). These researchers found that among teenage girls, more than 60% consumed less than one serving of fruit per day. The percentage of adolescent females not eating one serving of vegetables per day was not as significant, but increased profoundly when fried vegetables (especially french fries) were not counted. The authors of this study stated that the findings "may reflect a tendency of adolescent girls to restrict their energy intakes" (p.84).

Mineral Requirements

Low fruit and vegetable intake is only one of many concerns about the diet of teenage females. Iron deficiency is a risk for women and has been estimated to be as high as 20-30% (Cummings & Rewinski, 1996). "Iron deficiency is defined as depleted body iron stores without regard to the degree of depletion or to the presence of anemia" (Whitney et al., 1991, p.318). Most iron loss in women is the result of menstruation and diets low in iron (Cummings & Rewinski, 1996; Nattiv et al., 1996). Most of the body's iron is in the blood. Therefore, when blood is lost, iron loss is greatest. Women's blood loss during menstruation necessitates an iron intake twice as great as a man's (Whitney et al., 1991).

It is important that menstruating/premenopausal females eat foods high in iron. Iron rich foods include red meats, brown legumes, and some green vegetables. Since adolescent females tend to restrict their fat intake, they often avoid eating red meats. As discussed earlier, the female adolescent population also consumes well below the recommended daily allowance of fruits and vegetables. Another factor that increases a woman's risk for iron deficiency is the amount of food she consumes. Women tend to eat less than men because they are smaller on average. This decreases their chances of ingesting enough milligrams of iron daily (Whitney et al., 1991).

Some women also experience anemia along with iron deficiency. It is important to distinguish between iron deficiency with anemia and iron deficiency without anemia. "Iron deficiency refers to depleted body iron stores without regard to the degree of depletion or to the presence of anemia. Anemia refers to the hematological state resulting from a severe deficiency (of red blood cells). In the case of iron-deficiency anemia, the body's iron stores are completely depleted, and hemoglobin concentration is low" (Whitney et al., 1991, p.318). Although these two conditions are separate, people with iron deficiency without anemia are at risk for developing iron deficiency with anemia (Cummings & Rewinski, 1996).

The effect of iron deficiency without anemia on athlete performance is controversial (Eichner, 1992; Sherman & Kramer, 1989; Eichner, 1986). Most studies agree that iron deficiency with anemia increases fatigue and decreases performance (Eichner, 1992; Sherman & Kramer, 1989, Eichner, 1986). Most also conclude that iron deficiency without anemia does not decrease the performance of the athlete (Eichner, 1992, Sherman & Kramer, 1989). It also remains controversial as to whether iron deficiency is more common in female athletes than in the general female population (Sherman & Kramer, 1989). Even if it is not more common among female athletes, they are still at risk for the effects of iron deficiency simply by virtue of being female. A female athlete who exhibits symptoms of fatigue associated with iron deficiency may be increasing her risk for injury, especially late in competition.

Low calcium intake is another problem for adolescent female athletes. Many athletes maintaining low body weights choose food of low nutritional quality or simply do not ingest enough kilocalories to meet the recommended amount of calcium (Cummings & Rewinski, 1996). Crawford, Obarzanek, Morrison & Sabry (1994) found that many elite gymnasts were taking in only one half of the recommended daily allowance (RDA) of calcium (NIH Consensus Panel). It is recommended that adolescent females take in 1200 milligrams of calcium daily. This is one and a half times greater than the amount needed by premenopausal adult women (Mansfield & Emans, 1989). Mansfield and Emans (1989) report that the average adolescent female consumes less than 1000 milligrams of calcium daily.

Calcium is extremely important for several body processes. It is vital to the contractile ability of muscles, the formation of healthy teeth and bones, blood clotting, and nerve transmission. Sports such as basketball enhance bone formation because they are weight bearing activities (Manzoni et al., 1996). Bone formation, however, is a continuous process which necessitates the need for calcium to be supplied to the cells. If dietary calcium is low, the body will draw the needed calcium from the bones. This decreases the bone density and can lead to debilitating diseases or injuries such as osteoporosis and stress fractures (Cummings & Rewinski, 1996; Manzoni et al., 1996). Women are at an even greater risk for these diseases because their bones are thinner than men's, and because women lose bone density at a faster rate as they become older (Cummings & Rewinski, 1996). Adolescent females are neglecting to meet RDA standards for calcium at a critical point in their lives. Approximately 45% of the adult skeletal weight is laid down in adolescence (Dwyer, 1981). There is also evidence that suggests a woman may reach her peak bone density by age 20 (Arendt, 1993; Lloyd, 1993). After early adulthood their peak bone weight will decrease progressively with age (Manzoni et al., 1996).

There are several other factors that increase the risk for osteoporosis. Eating disorders and menstrual irregularity have a profound effect on bone density loss and the ability to reach peak bone density (Manzoni et al., 1996; Nattiv et al., 1996; Beim & Stone, 1995; Arendt, 1993; Yeager, Agostini, Nattiv, & Drinkwater, 1993; Mansfield and Emans, 1989; Lloyd et al., 1986). In fact, the prevalence of women who are at risk for developing an eating disorder, menstrual irregularity, or osteoporosis is amplified in women's athletics. The high frequency of menstrual irregularity and eating disorders among female athletes and the potential for premature osteoporosis has led to the invention of the term 'female athlete triad' (Nattiv et al., 1996; Nattiv, Agostini, Drinkwater, & Yeager, 1994; Yeager et al, 1993). According to Nattiv et al. (1994), this term refers to the "inter-relatedness of disordered eating, amenorrhea, and osteoporosis, disorders that may lead to significant morbidity and even to a high rate of mortality" (p.405). Eating disorders and menstrual dysfunction including amenorrhea will be discussed individually further in this chapter.

Ideal Body Weight

Body weight, by itself, offers little information concerning an individual's body composition. "Body composition refers to the relative amount of total body weight that is composed of fat, muscle, bone and water" (Whitney et al., 1991). The component that is often of greatest interest is fat. Several authors agree that optimal body fat for females is 16-25% (Houtkooper, 1996; Howley & Franks, 1992; Lohman, 1987). By using this optimal body fat range in combination with the individual's total body weight and percent body fat (found by using skinfold measurements and a prediction equation), an individualized ideal body weight range can be calculated (Preventative & Rehabilitative Exercise Committee of American College of Sports Medicine, 1991). This ideal body weight range is of much greater accuracy than the weight tables that are commonly used. These tables, created in the 1940's by Metropolitan Life Insurance Company, were developed by taking height and weight ratios from individuals buying their life insurance. They then selected the "desired" or "ideal" body weight ranges from those weights associated with the lowest mortality. Therefore, these weight charts are not accurate or representative of entire populations. They are merely gross estimates that do not factor in body composition or frame size. (Preventative & Rehabilitative Exercise Committee of American College of Sports Medicine, 1991).

By using a calculated definition of ideal weight (ideal weight = lean body weight/(1-desired % fat/100)) and comparing it to the subject's actual weight, those individuals falling outside their ideal weight range will be more accurately defined. This is due to the fact that total body weight, percent body fat, lean body weight, and optimal percent body fat will all be considered.

Research studies have shown that high ratios of lean body weight to fat weight are associated with better performance, yet they have also revealed that too little body fat may result in deterioration in both health and physical performance (Sinning, 1995; Wilmore, 1992). These studies continued by stating, "when an athlete's body weight drops below a certain desirable level, decrements in performance and increases in both minor and major illnesses and injuries are likely (Houtkooper, 1996, p. 160). This leads to the question of exactly how many female athletes fall into this "too little body fat" category which may lead to greater injury incidence.

Eating Disorders

The prevalence of eating disorders in young female athletes has been reported as high as 62% (Yeager et al., 1993). The most commonly cited range of prevalence is between 15 and 62% (Nattiv et al., 1996; Barnett & Wright, 1994; Nattiv et al., 1994). In the general female adolescent population, the prevalence of anorexia and bulimia is estimated at 1% and 3% respectively (Nattiv et al., 1994). There is also another 10% of women aged 16-25 in the general female population who do not meet the DSM-IV criteria (see appendix A) for anorexia nervosa and are said to have subclinical anorexia (Mehler, 1996).

It is difficult to acquire true prevalence statistics for several reasons. First, eating disorders are secretive in nature, and those that have them are often in denial of their symptoms. Secondly, studies are often of small sample size, and research in this area is limited (Nattiv et al., 1994). Lastly, the definition of disordered eating can be subjective because of its spectrum. Disordered eating behavior ranges from the strict DSM-IV criteria for anorexia nervosa and bulimia to “poor nutritional habits” (Nattiv et al., 1996).

Female athletes are thought to be at risk of falling within the disordered eating spectrum for several reasons. The psychological profile of a female athlete is often similar to that of a female with an eating disorder. The female athlete is often disciplined and devoted to performance. She is competitive, achievement oriented and is often a perfectionist (Barnett & Wright, 1994). Mansfield and Emans (1989) describe a person with anorexia as “classically an overachiever, often a straight A student who excels at academics and athletics through intense effort” (p.542). Many persons involved with modern athletics feed the athlete’s self requirements for perfection. The athlete’s team physician, coach, parents, certified athletic trainer, and school or athletic association administrators are all persons who may be adopting the win “at any cost” approach seen in many sports today (Yeager et al., 1993). Barnett and Wright (1994) have hypothesized that the western culture’s attitude may also result in the promotion of eating disorders among athletes. The culture’s obsession with thinness may lead the athlete to believe that a competitive edge will accompany an extremely lean body (Barnett & Wright, 1994).

Female athletes may be at an even greater risk to develop disordered eating because of their age. There are two peaks of age occurrence for anorexia. The first is at thirteen, when the teenager begins to deal with body image issues. The second peak is between the ages of seventeen and eighteen, when the adolescent begins to experience the stresses associated with increasing responsibility and separating from home. It has also been reported that this second group of seventeen to eighteen year olds has a poorer prognosis for recovery (Mansfield and Emans, 1989).

It is important to note that even though an athlete may not meet the strict DSM-IV criteria for an eating disorder, she may still be at an increased risk for developing serious skeletal, endocrine or psychiatric disorders (Nattiv et al., 1994; Yeager et al. 1993). Rock et al. (1996) studied the nutritional characteristics, eating pathology and hormonal status in young women. The study revealed that women who did not meet the full DSM- IV criteria for an eating disorder, yet still engaged in pathologic dieting behavior, had nutritional characteristics similar to those who did meet the full DSM-IV criteria. The researchers performing this same study also found that the nutritional feature most strongly correlated with eating pathology in young women was the reduction of dietary fat. This is important to note since a low fat intake can be associated with a decline in total energy (Rock et al., 1996). This in turn can play a role in the fatigue of an athlete. Johnson (1994) notes that disordered eating can increase injury risk. He states that "decreased caloric intake and fluid and electrolyte imbalances can result in decreased endurance, strength, reaction time, speed, and ability to concentrate" (p. 361).

Menstrual Dysfunction

Menstrual dysfunction is a term used to describe several menstrual irregularities that have the potential to occur in females. These irregularities, or a woman's current menstrual status, can usually be classified into one of four categories: (1) eumenorrhea, (2) oligomenorrhea, (3) amenorrhea, or (4) polymenorrhea (Nattiv et al., 1996). Nattiv et al. (1996) define these categories in the following manner: "Eumenorrhea: normal menstrual cycles" (p.845). Lloyd et al. (1986) further classifies this by adding "every 25-35 days or 10-13 menses per year" (p.375). "Oligomenorrhea: irregular menstrual cycle length of 35-90 days. Amenorrhea: absence of menstrual bleeding" (Nattiv et al., 1996, p.845). Amenorrhea is then further classified into two subcategories: primary and secondary amenorrhea. Primary amenorrhea is the absence of a menstrual period in a female who has not yet reached menarche. Menarche is the first menstrual period in a female's lifetime. This usually occurs between the ages of 12 and 15. Secondary amenorrhea is the cessation of menstrual periods in a woman who had previously established menstrual periods (Nattiv et al., 1996). There is no standard time length of cessation of menstrual periods to define secondary amenorrhea. However, Nattiv et al. (1996) state, "absence of menstrual periods for three to six consecutive months or more is commonly used" (p.845). Polymenorrhea has not been clearly defined in the literature; however, it is possible for a female to have more than 13 periods per year.

These definitions define menstrual status in relationship to the presence or absence of menstrual bleeding. Hormonal levels can also be used to describe menstrual dysfunction. Hormonal status can be dysfunctional and may or may not present as abnormal menstrual periods. These forms of menstrual dysfunction that do not present with abnormal menstrual periods may be more prevalent in the athletic population when compared to the general population but will not be discussed due to their exclusion from this study (Nattiv et al., 1996).

The prevalence of secondary amenorrhea in the general population is approximately 2-5 percent. When athletes are examined for menstrual dysfunction which includes amenorrhea and oligomenorrhea, this statistic can range anywhere from 3.4-

66%. (Yeager et al., 1993; Otis, 1992; Loucks & Horvath, 1985). Unfortunately, most studies fail to separate the categories of oligomenorrhea and amenorrhea or fail to define these categories adequately. This may lead to invalid prevalence statistics (Loucks & Horvath, 1985). Several studies also suggest that certain sports may have an increased rate of oligomenorrhea and amenorrhea. Athletes competing in performance sports such as gymnastics, figure skating, and dance and those competing in endurance sports such as distance running, may be at an increased risk because thinness is considered to give the athlete a competitive edge in these sports (Nattiv et al., 1996). Since there are several detrimental effects of menstrual dysfunction, even a small prevalence of athletic amenorrhea is cause for concern.

Theories

There are two theories that attempt to explain exercise associated menstrual dysfunction. The first theory hypothesizes that strenuous or endurance exercise activates the body's adrenal axis. The adrenal axis is then prevented from releasing hormones that facilitate the menstrual cycle (Nattiv et al., 1996; Arendt, 1993). The second theory is the theory of "energy drain". This theory states that if a female fails to take in enough kilocalories to meet the body's demands for energy during exercise, her body will respond by decreasing the basal metabolic rate which sacrifices follicular development (Nattiv et al., 1996). Whether one, or a combination of both of these theories, proves to be correct, the female athlete will be at risk. This is because it has been documented that many adolescent athletes have both an intense exercise regime and symptoms of an eating disorder (Mansfield and Emans, 1989).

Previously, it was thought that a certain percentage of body fat was necessary to initiate and maintain the menstrual cycle. This was called the "critical body fat hypothesis" (Frisch & McArthur, 1974). More recent research has suggested that menstrual cycles are not interrupted when body fat falls below a specific level (Sanborn, Albrecht, & Wagner, 1987; Ouellette, MacVicar, & Harlan, 1986). Although a specific level of body fat cannot be correlated with amenorrhea, an individualized level of body fat must be maintained for the athlete to be eumenorrheic (Loucks & Horvath, 1985). Newer research suggests a number of other causes for menstrual dysfunction. The causes may include chronic diseases, drugs such as opiates, psychological stress, poor nutrition (incorporating the theory of energy drain), intense athletic training, and endocrinopathies such as hypothyroidism (Mansfield and Emans, 1989).

Although body fat is obviously not the sole factor in determining the menstrual status of a female, its role cannot be entirely discounted. There are still several studies to date that suggest body fat does play a small part in menstrual dysfunction (Perry et al., 1996; Mansfield and Emans, 1989; Carlberg, Buckman, Peake, & Riedesel, 1983). More research studies suggest, however, that menstrual dysfunction may be the result of "energy drain".

Energy drain is postulated to occur when the body's energy demands are greater than the energy being supplied (Dueck, Manore, & Matt, 1996; Warren, 1980). The body must have a reservoir of energy stored in glycogen and body fat and can also draw upon energy consumed daily through food. This total energy reserve needs to balance with daily energy expenditure. Athletes with low caloric intakes or low total energy reserves may be at a greater risk for developing menstrual dysfunction (Dueck et al., 1996).

Although the mechanism behind energy drain is not thoroughly understood, there appears to be a strong correlation between weight loss or dieting and amenorrhea. Rock et al. (1996) studied seventy-six females from a major Midwestern university. The researchers determined that eating pathology was significantly correlated with ovulatory status. Those females taking in less total energy, carbohydrates, and fat were less likely to ovulate during their menstrual cycle than those who took in appropriate amounts of total energy, carbohydrates, and fat (Rock et al., 1996). It is interesting to note that subjects who did not ovulate derived approximately twenty-three percent of their energy from fat compared to their ovulatory counterparts who took in approximately thirty percent of their total energy from fat. There were, however, no differences in their body weight indices, or body fat percentages (Rock et al., 1996). Although loss of ovulation may or may not result in menstruation loss, this study demonstrates that inadequate energy or nutrient intake can result in menstrual changes.

Brooks, Sanborn, & Albrecht (1984) found that amenorrheic runners consumed significantly less meat and protein when compared to eumenorrheic runners. Another study done in 1985 cited a difference in caloric intake between amenorrheic and eumenorrheic athletes. The eumenorrheic group of runners was averaging a 2200 kilocalorie intake per day, while the amenorrheic group was averaging 1700 kilocalories per day (Braisted, Mellin, & Gong, 1985). It is important to note that this difference in caloric intake does not consistently present with weight loss. Warren's theory of energy drain was based on a study in which amenorrheic ballet dancers regained normal menstrual cycles without a change in body weight. This was after they had been sidelined with an injury. He, therefore, hypothesized that the exercise had drained their energy reserve, and normal menstruation returned when this reserve was no longer being depleted (Warren, 1980).

The principle of low caloric intake affecting menstrual cycle is supported when looking at patients with anorexia nervosa. Among anorexic females, one fourth developed amenorrhea before significant weight loss occurs (Mansfield and Emans, 1989). This would suggest that the nutritional characteristics of an anorexic subject were contributing to the subject's menstrual status more than weight loss. It is also well known that menstrual function regresses to a prepubertal level in patients with anorexia or other women on diets that promote severe weight loss (Rock et al., 1996). Also, many women with anorexia regain their menstrual periods when nutrient intake improves (Mansfield and Emans, 1989). These characteristics of anorexia nervosa patients tend to support the role of inadequate energy intake in menstrual dysfunction.

Side Effects

The side effects of menstrual dysfunction are numerous. The most publicized and potentially adverse effect of menstrual dysfunction is osteoporosis (skeletal demineralization) (Nattiv et al., 1996). Skeletal demineralization or osteoporosis is a disease in which bone weight density is decreased. Bone tissue thins and the growth of small holes in bone tissue occurs. Menstrual dysfunction can also cause women to fail to reach peak bone density. It has been theorized that women reach peak bone density by age 20. If this theory proves to be true, a woman with menstrual dysfunction in her teen years may never reach her peak bone density. This would place her at a greater risk for osteoporotic complications and injury in her later years (Arendt, 1993; Lloyd, 1993).

Menstrual dysfunction causes the body to enter a hypoestrogenic state. A hypoestrogenic body state has been associated with a loss of bone mineral density. This has been found in both postmenopausal women not receiving estrogen replacement therapy and in premenopausal athletes with menstrual dysfunction (Nattiv et al., 1996; Timmerman, 1996; Nattiv et al., 1994; Yeager, 1993; Mansfield & Emans, 1989). One study revealed that amenorrheic subjects had bone densities that were comparable to the average bone densities of women in their fifties (Drinkwater, 1984). Drinkwater, Nilson, & Ott (1986) found that in the fourteen months following the return of menses in amenorrheic women, vertebral bone density increased an average of 6.2 percent. However, in studies following this one, it became apparent that not all bone density loss is reversible (Drinkwater, 1990; Cann, Martin, H.K. Jaffe, & R.B. Jaffe, 1988).

Low bone density has serious complications for the athlete. In a study done in 1986, Lloyd et al., reviewed the medical charts of 207 women on various collegiate teams at Pennsylvania State University. The researchers found a four fold greater risk of stress fractures in the athletes with menstrual dysfunction when compared to the eumenorrheic athletes (Lloyd et al., 1986). Athletes may also be at risk for other bone disorders such as scoliosis and, as previously mentioned, osteoporosis (Benardot, 1996). It is important to recognize these risks in athletes because bone loss is extremely rapid, occurring a mere six months after the onset of amenorrhea (Drinkwater et al., 1986). Dueck et al. (1996) also note that "athletic amenorrhea represents more than just cessation of menstrual function: The associated hormonal aberrations have a negative impact on multiple systems in the body" (p.168). They also note that the negative impact can manifest as a variety of symptoms such as soft tissue injuries, fatigue, low energy, or hypothyroidism. These researchers also noted that an athlete's cognitive state can be altered which could decrease an athlete's awareness of the warning signs of an impending injury. This increases the risk of the injury being serious and threatening to the athlete's performance.

Women do not have to become amenorrheic to experience health complications, nor are bone injuries the only health complication of menstrual dysfunction. In a study of nineteen women training for over fourteen months in preparation for a marathon, eighteen women experienced menstrual changes but none became amenorrheic (Lloyd et al., 1986). Circulating levels of estradiol, however, dropped by over fifty percent. Estradiol is one of the most potent female hormones involved with menstruation (Perry et al., 1996). This study went on to note that women with irregular or absent menses experienced more injuries than women who were eumenorrheic (Lloyd et al., 1986). In this study, injury was defined as "any musculoskeletal ailment attributed to running that caused the runner to interrupt her running program and/or seek medical help" (Lloyd et al., 1986, p. 375).

Other complications of menstrual dysfunction include infertility, although thought to be reversible, and an increased risk for cardiovascular disease (Nattiv et al., 1996; Perry et al., 1996). Other studies have proposed that an increased risk of cancers of the uterus may accompany chronic amenorrhea (Otis, 1992; Loucks & Horvath, 1985). Menstrual dysfunction in athletes may also decrease the aerobic effects of exercise. One study on gymnasts has shown that amenorrhea combined with loss of bone density can counteract the positive effects of maintaining more lean muscle weight. This study proved that those athletes with increased lean muscle weight had a greater incidence of injury because their low bone density could not tolerate the torque produced by their muscles (Benardot, 1996). If female athletes can be educated about the importance of remaining eumenorrheic, many of these injuries and diseases could be prevented. It is also important that female athletes are treated for amenorrhea because their hormonal profile can lengthen the time necessary to recover from an injury or strenuous bout of exercise (Dueck et al., 1996).

One factor that has been shown to counteract some of the negative effects of menstrual dysfunction is the use of oral contraceptives. In the study done by Lloyd et al. (1986), women who used oral contraceptives were less likely to experience injury compared to women who had not used oral contraceptives. The effect of oral contraceptives on performance is under-researched and unknown to date. Although there is a lack of research in this area and conflicting conclusions among research, the general consensus is that females on oral contraceptives are protected from premature osteoporosis (Kulpa, 1993).

Research Equipment

For this study a tool that is capable of determining lean body weight needed to be selected. There are several methods available to predict LBM, yet all are not equal in reliability, validity, efficiency, cost effectiveness or accessibility. The most commonly found methods in the literature are: hydrodensitometry (hydrostatic weighing), bioelectrical impedance analysis, near-infrared spectrophotometry, and skinfold measurements. Each of these methods has benefits and disadvantages.

The first method, hydrodensitometry, is most often used in determining the validity of new methods or tools used to predict body composition. It is often referred to as the "criterion method" (Houmard et al., 1991; Jackson & Pollock, 1985). Hydrodensitometry has been documented to be one of the best methods available in predicting body composition. (Houtkooper, 1996; Jackson & Pollock, 1985). Although it has the highest validity, it is not an efficient way to test body composition. It is very time consuming, the equipment needed is large and difficult to transport, and a highly skilled operator must perform the test. For these reasons, hydrodensitometry is not often used in research which has large numbers of subjects.

Bioelectrical impedance analysis (BIA) has also been utilized in several recent studies, as it has become increasingly popular. BIA is established by the interrelation among the volume of the conductor, the height of the conductor, and its impedance (Houtkooper, 1996). Research shows its high reliability and operator friendliness. (Dolgener, Hensley, Becker & Marsh, 1992). However, its validity has been questioned. Several research studies indicate that BIA overestimates percent body fat in lean individuals (Dolgener et al., 1992; Hortobagyi et al., 1992), while other studies find it to be more accurate (Lukaski, 1987). The equipment needed is of moderate to high expense and is easily transportable. Overall, BIA is easy to use with mass subject testing, yet its current questionable validity makes it difficult to use in research.

The near-infrared spectrophotometry (NIR) incorporates the principles of light absorption and reflection (Houtkooper, 1996). This is one of the newest body composition prediction methods; therefore, limited research has been conducted with youths or adults. The procedure involves a fiber-optic probe placed in the mid-bicipital region, which emits an infrared light beam. The light beam pierces through subcutaneous fat and muscle and is reflected off the bone. The optical detector can then decipher this information to estimate body composition. (Houtkooper, 1996; Houmard et al., 1991; Lukaski, 1987). Research studies conducted by Conway, Norris, & Bodwell (1984) and

Houmard et al. (1991) revealed NIR overestimated and underestimated percent body fat when compared to skinfold measurements and hydrodensitometry. For this reason, NIR's validity is questionable. Another major drawback is the inability to generalize results because NIR's accuracy is dependent upon regional adipose distribution in relation to total body fat (Lukaski, 1987).

Skinfold (SKF) measurement is yet another method available to predict body composition. It is a more traditional field method that is often used clinically and with athletic teams. This approach is based on a two compartment theory. It states that the body can be broken down into two major compartments, fat-free weight and fat weight. Skinfold predictions also make two assumptions: (1) skinfold thickness is indicative of total body fat and (2) the skinfold sites selected are representative of average subcutaneous adipose tissue thickness (Lukaski, 1987). Body composition evaluation by skinfold method using standard technique has been proven valid. (Houtkooper, 1996; Hortobagyi et al., 1992; Houmard et al., 1991; Lukaski, 1987; Jackson & Pollock, 1985).

Although skinfold measurements are valid, efficient, and cost-effective, a certain amount of error is involved. This error, however, can be reduced if the tester undergoes proper training, if the appropriate caliper is chosen, if the caliper is used according to manufacturer guidelines, and if a suitable prediction equation is chosen for the population being tested. (Houkooper, 1996; Lukaski, 1987). Proper training has been suggested by an exercise physiologist to be five hours for two SKF sites.

Of these four methods, skinfold measurement was chosen as the method to predict body composition in this study. Not only is it valid and reliable, but it is also simple to use, cost effective, and accessible. Further review of literature regarding which caliper and equation is appropriate for this study will now be discussed. Sites at which measurements will be taken will also be discussed.

Calipers

In the literature cited, four caliper types were mentioned: Harpenden, Lange, Hotain, and Adipometer. Of these four, two were cited many times, the Harpenden and the Lange. Of these two, the research reveals discrepancies. Lohman, Pollock, Slaughter, Brandon, & Borleau (1984) performed a study comparing the accuracy of the Lange, Harpenden, Holtain and Adipometer. Their results suggested a higher standard error of measurements for the Lange and Adipometer. However, this standard error of measurement was less than + or - 1mm. (Lohman et al., 1984) There are also limitations to this study. First, the results of the skinfold measurements were compared to each other rather than to a criterion method. A criterion method, such as hydrodensitometry, should have been used for comparison purposes. This would have strengthened the validity of their data. Also, four investigators took the actual SKF measurements. Of the four investigators, each was familiar with different calipers (two with the Lange and two with the Harpenden). This also may have led to result discrepancies because each caliper is designed differently, and therefore, functions slightly differently. A second study comparing the Lange and Harpenden revealed little difference between sites (0.2 mm higher with Lange for a sum of four SKF sites) (Sloan & Shapiro, 1972). A third study done by Zando & Robertson (1987) found the Lange caliper to be valid when compared against hydrostatic weighing. A correlation of $r = .90$ has been determined between Lange caliper SKF measurements and hydrostatic weighing (Miller, 1984; Lohman & Pollock, 1981). The Lange Skinfold Caliper has also been the most widely used throughout the literature for SKF measurements (Stout et al., 1995; Jantz et al., 1993; Zando & Robertson, 1987; Jackson & Pollock, 1985; Thorland, Johnson, Fagot, & Hammer, 1984; Flint, Drinkwater, Wells, & Horvath, 1977; Jackson & Pollock, 1977). The Lange Skinfold Caliper was chosen for this study because it has been proven valid, cost effective, and easy to use. The caliper and personnel to train the researchers were readily available.

Prediction Equation

Selection of a SKF prediction equation is of great importance to this study. Lukaski (1987) states that no method or prediction equation is error free in estimating body composition. Lukaski continues by stating that the validity of SKF prediction equations are restricted to the population from whom the equation was derived. This means that for the purposes of this study an equation that is derived from youths ranging from 14-18 years, preferably females, would reduce error in predicting lean body weight. Jackson (1984) also points out that when evaluating the accuracy of a SKF prediction equation, the standard error estimate (SEE) is the most important statistic to consider. Jackson (1984) and Flint et al. (1977) both affirm the importance of prediction equation cross-validation prior to its use in any research study to confirm its reproducibility.

Therefore, when choosing a skinfold prediction equation each of these variables was considered. Slaughter et al. (1988) have taken a multi-component approach to predicting body composition. They have taken into consideration the chemical immaturity of adolescents and adjusted the adult prediction equations accordingly. One of the Slaughter skinfold equations was derived specifically for adolescent females. A cross-validation study was performed on the Slaughter skinfold equations for adolescents by Janz et al. in 1993. This study found the prediction equation designed for female adolescents using the triceps and subscapular SKF to be valid and reliable. Janz et al. state, "At this time, the Slaughter skinfold equations are perhaps the best anthropometric method for estimating percent body fat and fat free weight in children and adolescents. They appear to accomplish their goal with the same level of accuracy as commonly accepted adult SKF equations" (p. 1073). Using the triceps and subscapular sites for SKF measurement yielded a percent body fat SEE of 3.6%. This falls within the acceptable range and is actually lower than the original SEE of 3.9% found in the study by Slaughter et al. Total error and SEE value should be very similar because it reflects the relationship between the regression line of body density and predicted body density (Stout et al., 1995). The Janz et al. study supports this and confirms the female Slaughter equation because the total error and SEE values are identical. Therefore, the Slaughter prediction equation designed for female adolescents (using the triceps and subscapular SKF sites) was the best choice for this study, as it met all criteria and has been proven valid and reliable.

Measurement Sites

Skinfold measurements are done in several locations. The literature reveals that two to seven sites can be used for measurements. The chosen equation was derived for two site measurement, the triceps and subscapular regions. Therefore, the two sites that the equation describes will be used. If the number of sites or placement of sites was altered, the equation's reliability and validity would deteriorate. A study done by Jackson & Pollock (1985) found the sum of three and seven sites to be highly correlated, $r > 0.97$. This illustrates that little accuracy is lost when different combinations of SKF sites are utilized (Jackson & Pollock, 1985). Another study done by Lohman et al. (1984) found that using three or more SKF sites was not an advantage over the use of two SKFs. Lohman (1981) also reviewed several other studies which found two to three SKF sites to be adequate.

Conclusion

In conclusion, the review of literature shows basketball to be one of the highest injury risk sports, especially for the female population. When the ACL is considered, a 6-10 times higher rate of injury to this ligament is found in female basketball players when compared to their male counterparts (Hutchinson & Lloyd-Ireland, 1995; Emerson, 1993). Many factors, both intrinsic and extrinsic may contribute to this increased injury rate in female athletes. Inadequate nutrition, low lean body weight, and menstrual dysfunction have been suggested to play a role in causing injuries to runners and gymnasts (Nattiv et al.; Sinning, 1995; Wilmore, 1992; Lloyd et al., 1986).

More research is needed to determine if poor nutrition, low lean body weight and menstrual dysfunction are contributing to the increased rate of injury among high school female basketball players. If this research can demonstrate that these characteristics are potential risk factors, this may assist coaches, players, physical therapists, and trainers in identifying those athletes at risk for injury. This may ultimately aid in identifying injury prevention measures for female basketball players.

CHAPTER 3
METHODS AND MATERIALS

The design of this study consisted of four components: 1) a nutritional food frequency questionnaire, 2) a menstrual status questionnaire, 3) anthropometric measurements, and 4) an injury log.

Study Site & Subjects

The sites for our study consisted of participating area high school basketball teams' locker rooms. Site approval was requested from the teams' coaches as well as the schools' athletic directors.

Our subjects consisted of 138 high school female varsity basketball players. These athletes were between the ages of 14-18. Researchers required entire team participation in order to ensure an equal representation of all female basketball athletes' body types. Partial team participation resulted in exclusion from involvement in the study. Exceptions to this were if an individual athlete was excluded on the basis of age alone or if an athlete was on vacation at the time of data collection. Athletes were recruited from teams in lower Michigan, primarily the Lansing and Grand Rapids areas.

Researchers personally contacted area coaches to inform them about the study. Research purpose, methods, outcome benefits, as well as coach and athlete participation expectations were explained. Coach participation expectations consisted of: (1) approaching his/her team to determine if the players were willing to volunteer to be participants, (2) handing out parental and subject consent forms, (3) scheduling an appropriate test date, and (4) keeping record of any injuries that occurred throughout the girls basketball season (an injury data sheet/log was provided along with specific instructions on how to complete the log--see Appendices B & C). Injuries which the coach was expected to log were defined as any musculoskeletal ailment attributed to basketball that caused the player to miss the remainder of a practice or game, or miss any subsequent practices or games and/or caused the player to seek medical attention. The coach was asked to briefly describe the injury, document the medical diagnosis if medical attention was sought, record whether it occurred during a game or a practice, record who evaluated the injury, date and time of the injury, and date of return to play.

Subject participation expectations consisted of the following: (1) completing the nutritional food frequency questionnaire (See Appendix D) to the best of her ability, (2) completing the menstrual status questionnaire (See Appendix E) to the best of her ability, (3) allowing researchers to take skinfold measurements from the triceps and subscapular regions, (4) allowing researchers to weigh subjects, (5) consenting to injury recording, (6) bringing consent form to and from parent or legal guardian, and (7) signing consent form (See Appendix F). The researchers also answered any questions or concerns that the coach/participant/parent had.

After the coach received all above information in the mail to read over, approval was sought from the coach for the participation of his/her basketball team. Then the coach approached the team concerning the study to determine if the whole team agreed to participate in the study. The coach and the athletes were given letters which provided a brief explanation of the study (See Appendix G & H). This consisted of 1) the purpose of the study, 2) how the research relates to them, 3) participant expectations, 4) description of all procedures involved, and 5) parent and participant consent forms. The researchers required all consent forms to be signed prior to the date of subject testing. Phone numbers of researchers were made available to parents and athletes in the event of any questions.

Instruments

Research tools involved in the study were as follows: the Lange Skinfold Caliper, a nutritional food frequency questionnaire, and a menstrual status questionnaire. According to the Lange Skinfold Caliper Operator's Manual (1985) this caliper is "a precision instrument specifically designed for the simple, accurate measurement of subcutaneous tissue" (p.1). It is exclusively manufactured by Beta Technology Incorporated (1985). Research has proven the Lange to be a valid and reliable tool for measuring subcutaneous tissue. Its r value correlation was found to be 0.90 (Zando & Robertson, 1987; Miller, 1984; Lohman & Pollock, 1981). The Lange was used to measure skinfold thickness in two areas: 1) the triceps and 2) the subscapular regions on the subjects. The precise locations and procedures are discussed in detail in the procedure section of this chapter.

The next tool used was a portion of a Butterworth Hospital nutritional food frequency questionnaire. This type of questionnaire gives semi-quantitative and qualitative information concerning the frequency of food consumed in one week (Cummings & Rewinski, 1996). To date, the reliability and validity of this questionnaire have not been researched. Other more reliable and valid nutritional intake surveys were evaluated but were either inaccessible or inappropriate for this study. The questionnaire being used originated from the Health and Wellness Center at Butterworth Hospital in

Grand Rapids, Michigan. This questionnaire was given to each subject after the researcher gave explicit directions on how to properly complete the questionnaire. Directions were read from a script (see Appendix I) to ensure that all participants received the same information. Serving size portions were also shown to all participants to help them more accurately determine the quantity of food they consumed in an average week. One researcher, who was knowledgeable on specific serving sizes and was competent in answering any questions, administered the questionnaire. No time constraints were placed on subjects to complete the questionnaire, except that it needed to be completed on the testing day.

Following the food frequency questionnaire, a menstrual status questionnaire was administered. The researchers designed this questionnaire with the guidance of a physician and nutritionist; therefore, no reliability or validity data exist regarding this questionnaire. (To view scoring of the menstrual status questionnaire, see Appendix J). A pilot of the menstrual questionnaire was administered to 8 females aged 14-16 to ensure question clarity.

There are many benefits to using questionnaires. They are standardized and participants are asked the same questions in the same way. Questionnaires allow the subject adequate time to think about her answers and to consult the researcher with any questions that might arise. They also provide anonymity which encourages honest responses (Portney & Watkins, 1993).

Procedures

The researchers obtained a list of area female varsity basketball head coaches from a retired basketball coach. Researchers contacted coaches from this list and determined their interest in participation. Nineteen coaches expressed interest and were willing to approach their teams regarding this study. Of these 19 teams, 12 teams agreed to participate (this includes coach, athletic director, athlete, and parental consent). This resulted in 138 subjects.

Data collection began mid-August, which correlated with the beginning of girls basketball season. In order to obtain accurate skinfold measurements, data was collected prior to practice. Therefore, data collection opportunities were limited to before practices or games.

Skinfold data were obtained by the following step by step procedure. First, the anatomical site was marked with a skinscribe marker on the subject's skin, following the removal of any clothing covering the measurement site. The measurement sites that were used were, as mentioned previously, the triceps and subscapular region. The triceps site is defined as, "between the tip of the olecranon process of the ulna and the acromion process of the scapula" (Beta Technology Inc., 1985, p. 4). The subscapular site is defined as, "below tip of inferior angle, scapula 45° to vertical" (Beta Technology Inc., 1985, p. 6). All measurements were taken on the right side of the subject's body. Second, the tester firmly grasped the skinfold by her thumb and forefinger of the left hand and pulled it away from the subject's body. Third, the researcher applied the caliper jaws to the skinfold so that the pen mark was midway between the jaws and perpendicular to the skinfold. Fourth, the tester released her thumb from the caliper handle. Fifth, the reading was taken immediately following the first rapid fall on the caliper dial (Beta Technology Inc., 1985).

Three measurements at each site, for a total of six measurements, were taken on each subject. A minimum of 15 seconds between measurements was given to allow skin to return to its natural position. The average of the three measurements at each site was then computed. If one of the three measurements varied by more than 1mm, repeated measurements were taken until there was consistency among three of them. The new measurement average was then recorded. Each subject was also weighed separately using the same scale. The scale was calibrated upon arrival at each site. The subject's weight was recorded.

All three researchers were trained in how to measure skinfolds with the Lange skinfold caliper by a certified exercise physiologist. The exercise physiologist demonstrated the technique to the researchers and then observed their return technique. To enhance tester reliability, all researchers practiced performing skinfold measurements on female athletes and non-athletes for approximately five hours.

The same researcher performed the skinfold measurements on all subjects to eliminate problems with inter-tester errors. A second researcher recorded all skinfold measurements. This person observed the researcher taking measurements and gave input concerning appropriate caliper placement.

A researcher, who was not involved in the skinfold measuring or subject weighing, administered the two questionnaires. As subjects completed one portion of the study, either the questionnaires or the anthropometric measurements, they were directed to begin the next component.

The collected data remained confidential to protect each subject. Subjects were assigned numbers. These numbers were then used throughout the study instead of names. This study did not pose any potential hazards to our subjects. At any time, subjects were free to withdraw from the study.

CHAPTER 4
RESULTS/DATA ANALYSIS

Techniques

Data was collected and recorded at twelve individual high schools. Each subject's identification number was recorded on a data collection sheet (See Appendix K) with results of the athlete's skinfold measurement, weight, height, age, school, nutritional questionnaire score, menstrual status, and injury occurrence next to the subject's corresponding identification number.

To predict percent body fat from skinfold measurements, the Slaughter prediction equation was used. This equation is as follows:

$$\text{Percent Body Fat} = 1.33(\text{triceps} + \text{subscapular}) - .013(\text{triceps} + \text{subscapular})^2 - 2.5$$

If the sum of the skinfold was greater than 35mm then this equation was used:

$$\text{Percent Body Fat} = .546(\text{triceps} + \text{subscapular}) + 9.7$$

(Slaughter et al., 1988)

After calculating percent body fat, ideal body weight was determined by the following equation:

Pounds of fat = total wt. (lbs.) x body fat percent

Lean body weight (LBW) = total wt. (lbs.) – pounds of fat

$$\text{Ideal body weight range} = \frac{\text{LBW}}{1 - \frac{\text{desired \% body fat range}}{100}}$$

(Preventive and Rehabilitative Exercise Committee of the American College of Sports Medicine, 1991).

Descriptive Data Analysis

Descriptive data were obtained from the following: (1) menstrual and nutritional questionnaires, (2) subjective reports of age and height, (3) objective measurements of weight, and (4) derived measurements of body fat and lean body weight. Percentages, means, standard deviations, and ranges of these measurements are reported. Descriptive data analysis focuses on body composition, menstrual status, nutrition, and injury.

Body Composition

Table 4.1 summarizes descriptive data for age, height, weight, body fat, lean body weight, and percent lean body weight. The means, ranges, and standard deviations of these parameters, for the 138 athletes who participated in the study, are reported. Of particular interest, 33.4% of participants fell outside of their ideal body weight range as determined by the equation described previously in chapter 4, while 66.6% of the subjects fell within their ideal body weight range. Of the 33.4% of the athletes that fell outside of their ideal body weight 35 athletes (25.4%) fell above their ideal body weight range and 11 athletes (8.0%) fell below this range.

Menstrual Status

Table 4.2 summarizes the menstrual status of the 138 subjects. One hundred and four (75%) athletes, were eumenorrheic. Ten subjects (7%) were eumenorrheic and using

Table 4.1. Descriptive Data (n=138)

Subject Descriptive Data Summary			
	Mean	Range	Std. Deviation
Height	67"	62 - 74.5	2.74
Age	16 yr.	14 - 18	0.82
Weight	142 lbs.	99 - 214	19.45
Body fat %	22.09%	11.3 - 35.1	4.47
LBW	109.63 lbs.	83.7 - 146.6	11.4
LBW/total wt.	78%	58 - 88	5.0

oral contraceptives. Sixteen subjects (12%) were oligomenorrheic. An additional subject was oligomenorrheic and using oral contraceptives (.7%). One subject was premenarchal (.7%). Three athletes (2%) were having more than thirteen periods in one year and were placed in a polymenorrheic category. Three athletes (2%) were considered amenorrheic. Therefore, 16.7% of the athletes were considered to have menstrual dysfunction. Due to the small number of subjects that fell into categories other than eumenorrheic, statistical tests were no longer applicable when analyzing these various categories. Therefore, categories of menstrual status were condensed into two categories of eumenorrheic and "other". The "other" category consisted of those subjects whose menstrual status was amenorrheic, oligomenorrheic, polymenorrheic, premenarchal or any of these in combination with oral contraceptive usage. Subjects who were eumenorrheic and taking oral contraceptives were placed in the eumenorrheic category. The two categories then consisted of 115 (83%) eumenorrheic athletes and 23 (17%) "other" athletes.

Nutrition

Table 4:3 summarizes the results of the nutritional scores in individual categories. Scoring criteria for the nutritional questionnaire is found in Appendix L. The maximum

Table 4.2. Summary of menstrual status for female varsity basketball players (n=138)

Menstrual Status of Subjects		
Eumenorrheic	104	75%
Eumenorrheic using oral contraceptives	10	7%
Amenorrheic	3	2%
Oligomenorrheic	16	12%
Oligomenorrheic using oral contraceptives	1	0.7%
Premenarchal	1	0.7%
Polymenorrheic	3	2%

score possible on the nutritional survey was 110 points. Fifty-five points and above was considered adequate nutrition per 2/3 RDA standards. A score of fifty-four or lower was considered inadequate nutrition. The mean nutritional score was 39.25 +/- 16.41. The nutritional scores ranged from 6 to 95. The percentage of those having inadequate nutrition was 81.2%. Therefore, only 18.8% of the subjects were considered to have adequate nutrition.

Individual categories of the nutritional questionnaire were analyzed. Each individual category was scored between 0 and 10, with 5 being the passing score, 0 being the worst score, and 10 being the best score in each category. The athletes scored the best in the category of "lean meats, skinless poultry, etc...". This represents the fact that the athletes were eating closer to an appropriate amount of lean meats as compared to the foods in other categories. The athletes scored the lowest in the "cakes, cookies, etc..." category. This means the athletes were eating an overabundance of cakes and cookies.

Table 4.3. Summary of mean nutritional scores (n=138). 10=max, 5=passing, 0=min

Mean Nutrition Scores	Categories
2.31	Cakes, cookeis, pastries, doughnuts, chips, reg. Popcorn (inc.fat free snacks)
2.33	Candy, sugared drinks (pop, kool-aid, fruit punches)
2.70	Vegetables
2.75	Deep fried foods
3.06	Whole milk dairy products
3.20	Eggs and high fat meats
3.50	bread, cereal, rice, noodles, crackers, pretzels,dinner rolls, bagels, potatoes, flour tortilla, air or lite popcorn
3.94	Butter, margarine, oils, sour cream, dressings, cream cheese (not inc. fat free), bacon, gravy, nuts
4.20	Lowfat dairy products
5.32	Fruits or 100% fruit juices
5.93	Lean meat, skinless poultry, fish, dry beans, egg substitute, lean & trimmed beef and pork, tuna, wild game

Injury

Of the 138 subjects, 29 injuries occurred in 24 athletes based on the injury criteria described in chapter 3. Seventeen point four percent of the athletes were injured. The

Table 4.4. Summary of Injury Occurrence

Injury Occurrence (n=138)		
	#	percentage
Ankle sprains	15	10.9%
Knee injuries	6	4.3%
Contusions	5	3.8%
Fracture	1	0.7%
Shin pain	1	0.7%
Sprained thumb	1	0.7%

most common injury was an ankle sprain (n=15 or 10.9%). A summary of injury classification and occurrence can be found in Table 4.4.

Statistical Data Analysis

All statistical tests are summarized in table 4.5.Logistic regression was performed to identify relationships between the following: (1) injury and body fat, (2) injury and percent lean body weight, (3) menstrual status and percent lean body weight, (4) injury and lean body weight, and (5) body fat and menstrual status. Chi-square was used to analyze injury and ideal weight range. The Fisher's exact test (two-tailed) was performed to determine potential relationships between the following: (1) menstrual status and injury and (2) nutrition (pass/fail) and injury. Linear regression was used to determine if a relationship existed between the following: (1) percent lean body weight and nutrition score, (2) body fat and nutrition score, and (3) lean body weight and nutrition score. A t-test was used to determine if a relationship existed between nutrition

Table 4.5. Summary of Statistical Tests Performed

Variables	Statistical Test	P-value	R^2
Injury to % Body fat	Logistic Regression	0.83	0
Injury to % LBW	Logistic Regression	0.76	0
Injury to LBW	Logistic Regression	0.08	0.02
Menst. to % LBW	Logistic Regression	0.37	0
Menst. to % Body fat	Logistic Regression	0.28	0
Injury to ideal body wt.	Chi Square	0.69	N/A
Menst. to injury	Fisher's Exact	0.76	N/A
Nut. (pass/fail) to	Fisher's Exact	0.07	N/A
% LBW to nut. score	Linear Regression	0.08	0.02
% Body fat to nut.	Linear Regression	0.003	0.06
LBW to nutrition score	Linear Regression	0.003	0.06
Menst. to nutrition	Independent t-test	0.92	N/A
Injury to nutrition	Mann-Whitney U	0.87	N/A

score and menstrual status.

A Fisher's exact test is performed when a Chi square analysis is invalid. A Chi square is invalid if one or more of the four categories has fewer than five subjects fall within a category. In order to perform a Fisher's exact test (two-tailed), both variables can only be one of two values. For this reason, when analyzing the nutritional scores by the Fisher's exact test, the scores were divided into subcategories of pass/fail. Those athletes scoring less than 55 points on the nutrition questionnaire received a "0" for failing the questionnaire, and those athletes scoring 55 points or higher received a "1" for passing the nutritional questionnaire. In instances when statistical tests other than Fisher's exact were being used to analyze the nutritional data, actual nutrition scores were used. Therefore, in the above and below paragraphs a distinction is made between data analyzed using actual scores and data using the pass/fail categories.

No statistical significance was found to explain injury by the following: (1) body fat, (2) lean body weight, (3) nutrition scores, (4) percent lean body weight, (5) ideal body weight range, or (6) menstrual status. However, high lean body weight as a predictive factor of injury is approaching statistical significance with a p-value of .08. Although this relationship is approaching statistical significance, it cannot be considered clinically significant because the coefficient of determination is .02.

Another relationship approaching statistical significance is nutrition (pass/fail) as a marker for injury with a p-value of .07. When further statistical analysis was performed using the Mann-Whitney U test, which allowed the researchers to use the *actual* nutritional scores, no relationship was found between injury giving a p-value of .87. The Mann-Whitney U test nullifies the clinical significance of nutrition (pass/fail) as a marker for injury. Further explanation is discussed in chapter 5.

No statistically significant relationships were found between the following: (1) menstrual and percent lean body weight, (2) nutrition score and percent lean body weight, and (3) body fat and menstrual status. Also approaching statistical significance was the relationship between menstrual status and nutrition scores. The athletes' menstrual statuses predicted their nutrition scores with a p-value of .08. Those athletes who were eumenorrheic scored lower (mean nutrition score = 38) on the nutritional questionnaire than those athletes who were in the menstrual dysfunction category (mean nutritional score = 44). However, this relationship is not clinically significant due to the small variation in nutritional mean scores and a large standard deviation in both categories (standard deviation +/-15, +/-16 respectively). Approaching statistical significance with a p-value of .08 is nutritional score as a marker for the athletes' percent lean body weights. However, the coefficient of determination (.02), suggests this relationship is not clinically significant.

Data analysis also concluded that the athlete's nutrition was a marker of the athlete's body fat percentage with a p-value of .0032. The coefficient of determination for this relationship is .06, suggesting that this relationship is not clinically significant. Data analysis also revealed that nutrition score was a statistically significant marker for lean body weight with a p-value of .003. The higher the athlete's nutrition score, the higher their lean body weight. The coefficient of determination (.06) suggests that, although statistically significant, the relationship is not clinically significant.

Hypotheses

The researchers were unable to reject the null hypotheses: (1) the eumenorrheic status of female high school varsity basketball players will not show a significant relationship ($p<.05$) with injury occurrence during one basketball season; and (2) a total score of 54 or less (inadequate nutrition) on the food frequency questionnaire completed by a female varsity basketball player will not show a significant relationship ($p<.05$) with that athlete's injury occurrence during one basketball season.

CHAPTER 5
DISCUSSION AND IMPLICATIONS

Discussion of Findings

Many views on the contributing factors to the high incidence of athletic injuries among female basketball players exist. Although this study failed to find statistically significant explanations for this high injury incidence, it did provide data that show high frequencies of inadequate nutrition and body weights that were outside of the ideal body weight range. Inadequate nutrition and lean body weight that are not optimal may still be considered risk factors for injury, especially if these factors are in combination with intrinsic factors. Examples of these intrinsic factors, which may predispose an athlete to injury, are increased Q-angle, a narrow intercondylar notch, and muscle recruitment order.

The researchers have surmised possible explanations for the results of this study. When looking at lean body weight as a marker for injury without considering the *percent* lean body weight (lean body weight/total body weight), the results are misleading. Most athletes with high lean body weight also had the lowest *percentage* of lean body weight. This was because these athletes had higher body weights and higher body fat percentages. This lower amount of muscle weight in relationship to fat may predispose the athlete to injury. This may explain why high lean body weight as a predictor of injury is approaching statistical significance. However, the coefficient of determination for this relationship is .02, which suggests that 98% of the athletes' injuries are not explained by their nutrition. According to Portney and Watkins (1993), a coefficient of determination

(r^2) is "a measure of proportion, indicating the accuracy of prediction based on X [injury]." Therefore, "1 - r^2 reflects the proportion of variance that is not explained by the relationship between X [injury] and Y [nutrition]".

When analyzing nutrition score as a marker for percent lean body weight, the results are approaching statistical significance ($p=.08$). The higher the nutrition score, the lower the ratio of muscle to fat. However, the coefficient of determination ($r^2=.02$) again nullifies the clinical significance of this relationship. Based on previous literature, the researchers would have expected the percent lean body weight to increase as the nutrition score increased. A possible explanation for these results may be that the nutritional questionnaire was not a sensitive tool for the population researched in this study.

It is also possible that the relationship between menstrual status and injury prevalent in runners and gymnasts does not exist among basketball athletes secondary to a decreased prevalence of menstrual dysfunction among basketball athletes. This study indicated that 16.7% of the athletes surveyed had menstrual dysfunction. This statistic is much lower than the percentage of runners and gymnasts shown to have menstrual dysfunction, estimated as high as 66% in previous studies (Yeager et al., 1993; Otis, 1992; Loucks & Horvath, 1985). Runners tend to present with a different body type and composition than basketball athletes. Runners may tend to think that a leaner body is advantageous in this sport. This leaner body, however, may predispose them to menstrual dysfunction. Basketball athletes may feel it is an advantage to maintain an appropriate weight and amount of body fat for their sport, which may lessen their risk for menstrual dysfunction.

However, the 16.7% of athletes found with menstrual dysfunction in this study still remains much higher than the 2-5 % observed in the general population (Yeager et al., 1993; Otis, 1992, Loucks & Horvath, 1985). Although the researchers have no explanation for the higher incidence of menstrual dysfunction among female high school varsity basketball athletes, this finding is of clinical importance. This study did not find a correlation between menstrual dysfunction and injury, but many other studies have shown significant correlations between menstrual dysfunction and osteoporosis (Arendt, 1993; Lloyd, 1993). The injury log in this study was only kept for one season. Osteoporotic complications may take years to develop (Arendt, 1993; Llyod, 1993). The basketball athletes exhibiting menstrual dysfunction in this study are at an increased risk for developing these osteoporotic complications later in life.

The relationship between nutrition (pass/fail) and injury was found to be approaching statistical significance (p=.07). Pass/fail categories for nutrition scores were used in the Fisher's exact (two-tailed) analysis. However, the Mann-Whitney U analysis, based on *actual* scores, is a more powerful analysis for these data. The Mann-Whitney U test revealed no statistical significance (p=.87). Further investigation of the data for this relationship revealed a clustering of injuries occurring near the cut-off score of 54 for adequate nutrition. This clustering explains why the Mann-Whitney U test found no statistical significance. The mean difference in nutrition scores between those athletes who were injured (37.5) and those who were not (39.7) is too small to reveal statistical significance.

Although a relationship was not identified between nutrition and injury, the nutritional questionnaire did reveal that only 18.8 % of the participants in this study exhibited appropriate nutritional profiles as defined in this study. This may be due to decreased time, intense practice schedules, and the increased availability of fast food to high school students.

Categories which the athletes scored especially low in were "cakes, cookies, pastries, etc…", "candy and sugared drinks", and "vegetables". The poor scores in these categories suggest that athletes are drinking sugared beverages for the majority of their fluid intake. Scores in the dairy product categories were also considered to be inadequate. This suggestion is problematic when one considers the amount of calcium recommended for adolescents. If the athletes were not taking in calcium in the form of milk or other dairy products, they are at an increased risk for osteoporosis. If these athletes also had menstrual dysfunction or inadequate nutrition in other categories, they may be at risk for debilitating diseases as exemplified by the female athlete triad which is discussed in Chapter 2. This malicious cycle can potentially be broken by education regarding proper nutrition, eating habits, and calcium intake.

The relationship between menstrual status and nutrition that was approaching statistical significance ($p=.08$) may be best explained by the physiology of the female menstrual cycle. This relationship suggests an athlete with menstrual dysfunction had higher nutrition scores. Stress, body composition, body weight, and hormonal influences are known to affect the menstrual cycle. Nutrition may be yet another factor that can affect the female menstrual status because it affects body weight and composition. However, the difference between the mean nutritional scores for the eumenorrheic group (38) and the menstrual dysfunction group (44) was not great enough to confidently propose a relationship between menstrual status and nutrition. This finding may again be attributed to the use of an insensitive tool for nutritional analysis in this population.

Application to Practice

Although a statistically or clinically significant relationship between the athlete's nutrition score and her injury risk was not found, a large proportion of the athletes still exhibited characteristics of poor eating habits. Only 18.8 % of the athletes practiced proper nutritional habits as defined by this study. Even though this nutritional questionnaire may have been too insensitive to predict a relationship between nutrition and injury, the questionnaire still revealed that the athletes were eating inappropriate amounts of certain desirable and undesirable foods. Coaches need to be aware of the nutritional habits of their athletes and promote positive eating habits among the athletes. Nancy Clark, a registered dietician suggests a "food as fuel" concept when educating young women about proper nutritional habits. This concept focuses on promoting proper food as something the body needs to perform daily and sport related activities rather than an enemy that creates weight gain (Clark, 1993). Physical therapists and other health professionals also need to be aware of their patients' nutritional habits to promote better health.

The researchers also received many questions during data collection regarding food sources and amounts appropriate for the athletic and basic daily diet. These questions may represent a lack of knowledge among coaches and athletes regarding proper nutrition. Physical therapists and other health care providers should take advantage of the opportunity to educate coaches and athletes about proper nutrition to fuel the body for athletic competition.

The prevalence of menstrual dysfunction among female high school varsity basketball players in this study was found to be higher than that found in the general female population. Therefore, it is important to educate athletes on the complications of menstrual dysfunction. Seeking medical attention for menstrual dysfunction may help prevent osteoporotic complications in the future.

Limitations

Due to several unavoidable factors, there are limitations to this study. One of these is the fact that all teams were selected from lower Michigan (specifically the Grand Rapids and Lansing areas). This selection was due to time constraints of the researchers. This population may not have exhibited an equal distribution of socioeconomic classes or races.

Another limitation of this study is that standardized surveys were not used and the reliability of self-report for questionnaires is uncertain. The personal nature of questions regarding menstruation, birth control, and eating habits may also contribute to decreased reliability. The menstrual questionnaire was piloted to ensure that it was clear and concise. The girls who took part in this pilot study answered all questions appropriately and did not have any questions about how to answer the questions. The nutritional questionnaire was not piloted because it was based on portions of a survey designed by Butterworth Hospital of Grand Rapids, Michigan. Although the Butterworth survey was not standardized either, it is used on a daily basis by the hospital, but not in this form or for this population.

The nutritional questionnaire revealed some problems, however, when it was administered to the athletes. The athletes had difficulty with the math that was necessary to complete the survey. They also had difficulty thinking back for an entire week to determine what foods they had consumed in an average week. The athletes experienced difficulty determining which foods fell into which categories. If the athletes asked the researchers questions about the categories, the questions were answered and the information was considered accurate. Some of the athletes may have felt uncomfortable asking questions, however; and they may have simply guessed where the information best fit. The researchers also suspect that a few of the girls may have had learning disabilities. This may have impacted the athletes' abilities to complete the survey accurately. A food diary recorded by the athlete and analyzed by the researchers may have eliminated some of these problems, thereby strengthening the study.

Another problem with the nutritional questionnaire is that the researchers were unable to control discussions among the athletes while they were completing the questionnaire. The athletes' responses may have been influenced by their friends and teammates' opinions and answers. An effort was made by the researchers to control these discussions, but some of the athletes were non-compliant with these conditions.

The largest problems with this nutritional questionnaire were how it was scored and the fact that it had no way to record caloric intake. The dietician-based scoring did not penalize the participants for eating an excessive amount of a desirable food, such as lean meats. The questionnaire also did not make a distinction between someone who ate 30 servings of cookies or someone who ate 15 servings of cookies per week. Both participants would have received 0 points for eating these excessive amounts of cookies. This lack of distinction may account for some of the small differences in nutrition scores between groups being examined such as injured and non-injured.

The failure of the nutrition questionnaire to estimate caloric consumption may help explain why a relationship between nutrition and injury was not shown. Low-caloric consumption has been associated to fatigue which has further been associated with an increased risk of injury (Eichner, 1992; Sherman & Kramer, 1989). Since no distinction was made among the athletes for varying amounts of caloric consumption, an increased risk for injury among those who consumed too little calories to fuel their body could not be investigated. Furthermore, the lack of caloric measurement may have skewed the results for relationships between nutrition and body fat and nutrition and percent lean body weight. Athletes that were determined to have appropriate nutrition in this study may have been consuming too many calories leading to an increased body fat and a decreased percent lean body weight. Physiologically, too many calories, regardless of what form they are in, will result in their conversion to body fat when not burned during activity (Whitney, 1991).

Another limitation of the study is that the injuries were only logged for one season. This was unavoidable due to time constraints. Tallying the injuries over a longer length of time would have strengthened the study, since basketball season is fairly short and injury risk would increase over a longer length of time. Also, a record of playing time was not kept. The amount of playing time may have altered the risk of injury among those players who did not experience much game playing time, although the majority of the injuries in this study occurred during practice. Variations in conditioning and training were also not taken into account in this study.

The researchers were dependent upon the coaches and athletic trainers to record the injuries. Although the trainers and coaches did not report any problems, there is a possibility that injuries were missed, inaccurately recorded, or not reported to the coach by the athlete.

Finally, the actual skinfold measurement itself carries a 3-4% error, whereas hydrostatic weighing decreases this percent error to 1.5-2.5%. However, due to equipment accessibility, as well as subject compliance, the researchers were unable to use hydrostatic weighing, and feel that 3-4% error is acceptable.

Suggestions for future research

In discussions with the athletes and coaches, the researchers discovered a variation among the conditioning and practice schedules of the teams. Some teams included weight training while others did not. The conditioning and training practices of the athletes and the relationship to injury may be useful information to obtain in the future. Another suggestion for further research would be to study the impact of the factors examined in this study on injury over a longer period of time. Since nutrition, menstrual status, and lean body weight may exhibit long-term effects on an athlete's health, it would be wise to study the relationships over several years rather than a sole season.

This study could be modified to improve accuracy and reliability. A food record/diary could be substituted for the nutritional survey. The athletes would be required to record each item and amount that they consume for an entire week, rather than trying to recall their average consumption for a week. This information could further be analyzed using a computer-generated program. The survey administration could be improved by separating the athletes to eliminate the discussions. A record of the playing time for each athlete could be kept to enhance this study. Most likely, the athletes' amounts of playing time were highly variable. This variability impacts the athletes' chances of becoming injured. If an athlete had poor nutrition or an undesirable menstrual status, she may have avoided injury simply because she rarely experienced any playing time in games. Conversely, if an athlete had adequate nutrition and a normal menses, she may have been the athlete who played more and this may have consequently increased her risk of injury.

Future studies could focus on the replication of this study using different populations of athletes and various sports. For example, this study could examine high school, collegiate, or professional athletes in basketball, soccer, gymnastics, running, softball, etc. Examining the prevalence of eating disorders among high school female basketball athletes and these other groups is also a suggestion for future research.

Another idea for future research is to examine the relationship between the hamstring/quadriceps peak torque ratio and the athletes' lean body weights. The ratio between hamstring to quadriceps peak torque has been examined in the past as a possible cause of injury among female basketball players. If a relationship exists, it may suggest that an athlete could reduce her chances of injury by improving her lean body weight and thus affecting her hamstring/quadriceps peak torque ratio.

Conclusion

In conclusion, nutrition, low lean body weight, and menstrual dysfunction have been suggested to play a role in causing injuries to runners and gymnasts (Nattiv et al.; Sinning, 1995; Wilmore, 1992; Lloyd et al., 1986). Although this study did not statistically support the same finding among female high school basketball players, it did identify several problems among high school female basketball players. Many athletes exhibited poor nutrition, menstrual dysfunction, and inappropriate body fat percentages and total body weights. Perhaps with a larger sample size or improved methodology, statistically significant relationships may have been shown for menstrual dysfunction, percent lean body weight, and nutrition as markers for injury. More research is warranted to further investigate these relationships.

This study verifies the need for education of coaches and athletes regarding proper nutritional habits and identifies poor nutritional habits in female basketball players from many high schools. This study also illustrates the need for education regarding the complications of menstrual dysfunction if medical attention is not sought. As prominent members of the health care team, physical therapists have an obligation to educate the community regarding factors that may aid in the prevention of injury.

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APPENDIX A

DSM-IV CRITERIA FOR ANOREXIA NERVOSA

Refusal to maintain body weight at or above 85% of normal weight for age and height.

Intense fear of gaining weight or becoming fat, despite being underweight.

Disturbance in the way in which body weight or shape is experienced, undue influence of body shape or weight on self-evaluation, or denial of the seriousness of current low body weight.

Amenorrhea in postmenarchal girls and women (missing at least three consecutive menstrual cycles or having periods only after administration of a hormone such as estrogen).

Restricting Type: During the episode of anorexia nervosa, patient does not regularly engage in binge-eating or purging behavior (i.e., self-induced vomiting or misuse of laxatives, diuretics, or enemas).

Binge-Eating/Purging Type: During the episode of anorexia nervosa, patient regularly engages in binge-eating or purging behavior.

Adapted from the American Psychiatric Association's Diagnostic and Statistical Manual of Mental Disorders, fourth edition (DSM-IV).

DSM-IV CRITERIA FOR BULIMIA

Recurrent episodes of binge eating in a discrete period of time involving more food than most people would eat. There is a sense of lack of control over eating during episodes.

Recurrent inappropriate compensatory behavior to prevent weight gain, such as self-induced vomiting; misuse of laxatives, diuretics, enemas, or other medications; fasting; or excessive exercise.

Both binge eating and inappropriate compensatory behaviors occur on average at least twice a week for three months.

Self-evaluation in unduly influenced by body shape and weight.

The disturbance does not occur exclusively during episodes of anorexia nervosa.

Purging Type: During the episode of bulimia nervosa, the patient regularly engages in self-induced vomiting or misuse of laxatives, diuretics, or enemas.

Nonpurging Type: During the episode of bulimia nervosa, the patient uses other inappropriate compensatory behaviors, such as fasting or excessive exercise.

Adapted from the American Psychiatric Association's Diagnostic and Statistical Manual of Mental Disorders, fourth edition (DSM-IV).

APPENDIX B

INJURY DATA/LOG

Name	Date of Injury	Game or Practice	Time	Injury Description	Medical Diagnosis	Return to Play

APPENDIX C

INSTRUCTIONS FOR INJURY LOG

This injury log should be started on the **FIRST DAY** of team practice. When a basketball player is injured, the coach or athletic trainer should record the players name (which will later be coded as a number), the date of injury, if it was during a practice or a game that the player was injured, the approximate time the injury occurred (i.e. "first quarter, middle of practice, etc.), a brief description of the injury, and later, when the player returned to practice. For example, if a player injured her ankle, indicate the joint affected-"ankle"- and just a brief description of how it was injured such as "coming down from a rebound" or "twisted it while turning a different direction", etc. Next, if a medical diagnosis is later given by an athletic trainer or doctor, please indicate the medical diagnosis given in the second to last column.

The definition of injury is as follows: any musculoskeletal ailment attributed to basketball that caused the player **to miss the remainder of a practice or game, or miss any subsequent practices or games and/or sought medical attention**. So if a player jams a finger, has it taped on the sidelines, and returns to play, this is not considered an injury for our purposes. However, if this player was still having problems with this injury and seeks medical attention it would then be documented on the injury log.

If a player has sustained an injury before the first day of practice, causing her not to participate in that practice or any subsequent practices, please fill out the log accordingly. For example, in the date column please write **previous injury** and the only other columns necessary to fill out are the injury description (what joint affected) and when the player returned to practice.

If you have any doubts as to whether something qualifies as an injury, it is better to record it and the researchers will determine later if it is appropriate. If there are any questions regarding this injury log please feel free to contact Kristie Wood at 892-5242. Thank-you for your time and participation in this study. It is greatly appreciated.

APPENDIX D

Food Frequency Questionnaire

Participant I.D. # ____________________

High School ____

Sample Food Items	Serving Sizes	Number of servings ___ week
a. Bread, cereal, rice, noodles, crackers, pretzels, dinner rolls, bagels, potatoes. flour tortilla, air or lite popcorn	1 slice of bread, 1/2 cup cooked rice or noodles, 1/2 cup cooked cereal, 1 ounce ready-to-eat cereal, 1 roll, 3 cups popcorn	
b. Fruits or 100% fruit juices	1 small piece fresh, 1/2 cup canned, 1/4 cup dried, 3/4 cup juice	
c. Vegetables	1/2 cup chopped raw or cooked, 1 cup leafy raw	
d. Lowfat dairy products (skim, 1/2% or 1% milk, lowfat yogurt or frozen yogurt, ice milk, lowfat cheese)	1 cup of milk or yogurt, 1.5 - 2 ounces of cheese, 1/2 cup ice milk	
e. Lean meat, skinless poultry, fish, dry beans, egg substitute, lean & trimmed beef and pork, tuna, wild game	3 ounces cooked meat, poultry or fish, 1/2 cup cooked beans, 1 egg substitute	
f. Whole milk dairy products (whole or 2 % milk or yogurt, ice cream, cheese, pudding)	1 cup of milk or yogurt, 1.5 -2 ounces of cheese, 1/2 cup ice cream	
g. Eggs & high fat meats (sausage, luncheon meats, salami, bologna, corned beef, hot dogs, hamburger, ribs); peanut butter	3 ounces cooked meat, poultry or fish, 1 egg, 1 tablespoon peanut butter	
h. Deep fried foods (meat, poultry, fish, vegetables, potatoes)	3 ounces cooked meat, 8-10 fries	
I. Butter, margarine, oils, sour cream, dressings, and cream cheese (not including fat free), bacon, gravy, nuts/seeds	1 teaspoon butter, margarine or oil; 1 tablespoon dressing, nuts or seeds; 1 slice bacon	
j. Cakes, cookies, pastries, doughnuts, chips, regular popcorn (include "fat-free" snacks)	1/8 pie, 2-inch square of cake, 1 handful of chips (approx. 15), 2 cookies	
k. Candy, sugared drinks (pop, Kool-Aid, fruit punches)	12 ounce sugared pop or drink	

APPENDIX E

MENSTRUAL QUESTIONNAIRE

Identification Number: Age:

1. Please check one of the following statements which is true for you.

   ☐ A. I have never had a period.
   ☐ B. I have had a period previously.

2. If you checked answer A, your survey is complete and you may turn it in. If you checked answer B, please check the statement that most accurately describes your periods within the last year.

   ☐ A. I have had 10-13 periods in the last year.
   ☐ B. I have had less than 10 periods in the last year, but I have had a period within the last three months
   ☐ C. I have not had a period in the last 3 months.
   ☐ D. I have had more than 13 periods in the last year.

3. Please check the appropriate response to the following questions:

   Are you currently taking oral contraceptives (birth control pills) or receiving an injected form of contraceptive (Depo-Provera shot)?

   Yes ☐ If yes, please list kind ______________________________
   No ☐

4. Have you been pregnant or nursed a baby within the last year?

   Yes ☐ No ☐

5. Are you currently pregnant or nursing a baby?

   Yes ☐ No ☐

6. Please list any medical condition, disorder, or disease that you have or have had in the last year.

   ____

APPENDIX F

CONSENT FORM

I understand that I am participating in a study that will record nutritional status, menstrual status, lean body weight, and injury occurrence from approximately 100 athletes. Both nutritional status and menstrual status will be determined using a brief written questionnaire which I will complete. Lean body weight will be measured using a skinfold caliper at the triceps and subscapular (mid back) regions and by total body weight. Injury occurrence will be recorded throughout the regular season by either the coach or school athletic trainer. I also understand that the knowledge gained from the questionnaires, lean body weight, and injury log is expected to help physical therapists, certified athletic trainers, coaches, doctors, and athletes to better identify those athletes at a potentially higher risk for injury and intervene with preventative measures prior to injury occurring.

I also understand that:

1. I was selected because I am a member of the girls high school varsity basketball team, and I am between the ages of 14-18 years old.

2. there are no potential risks involved in participating in this study.

3. information I provide will be kept strictly confidential and the data will be coded so that identification of individual participants will not be possible.

4. a summary of results will be made available to me upon my request.

5. I will be given verbal and written instructions on how to properly complete each written questionnaire.

I acknowledge that:

"I have been given an opportunity to ask questions re: this research study and that those questions have been answered to my satisfaction."

"In giving my consent, I understand that my participation in this study is voluntary and I may discontinue the study at any time during the testing."

"I hereby authorize the investigator(s) to release information obtained in this study to scientific literature. I understand that I will not be identified by name."

"I have been given the researchers names, Megan Pavlak, Robyn Smith, and Kristie Wood, and phone number, (616) 892-5242 so that I may contact them if I have questions."

"I have been given the phone number of Paul Huizenga, the director of Human

Subjects Review Board at Grand Valley State University, 895-2472, so that I may contact him if I have any questions regarding my rights as a participant in this study."

"I acknowledge that I have read and understand the above information and that I agree to participate in the study."

____

Signature of athlete

____

Signature of parent (if athlete< 18 years old)

____

Signature of witness (must be at least 18)

APPENDIX G

CONTACT LETTER

Dear (Athletic director, Coach, Athletic trainer),

We are graduate students in Grand Valley State University's Masters of Physical Therapy program and are looking for female high school varsity basketball teams to volunteer to be part of our Master thesis study.

Basketball is known to be one of the highest injury risk sports, especially for the female population. A study by DuRant et al.(1992) demonstrated that female basketball players experienced athletic injuries at a rate similar to that of male football players. When the ACL is considered, a 6-10 times higher rate of injury to this ligament is found in the female basketball player when compared to their male counterpart.

Our study is looking at the relationship between low lean body weight, nutritional status, menstrual status, and injury rate. These possible factors in injury have not been researched in great detail and this study is to fill these gaps. The results of our study could have considerable implications for the prevention and treatment of injuries in the female basketball athlete.

We need female varsity basketball teams to volunteer to fill out a nutritional and menstrual survey, as well as have their percent body fat measured. We must have whole team participation to have validation to our study. The athletes will receive this confidential analysis free of charge and can request to see their individual results at the end of the study. Overall research results may also be obtained in May 1998.

If your school's girls varsity basketball team is interested, please have the athletes and parents sign the enclosed consent form to be eligible for participation. We will be contacting you shortly after you receive this packet. An injury log is also enclosed and needs to begin on the first day of practice (please see attached directions). Testing will be performed right at your school in a room designated by the coach or appropriate school official, and must be before the athletes practice for correct results.

Thank You,

Robyn Smith S.P.T.
Student Physical Therapist

Kristie Wood S.P.T.
Student Physical Therapist

Megan Pavlak S.P.T.
Student Physical Therapist

APPENDIX H

PARENT/ATHLETE INFORMATION LETTER

Dear Parents and Athletes,

We are graduate students in Grand Valley State University's Masters of Physical Therapy program. We are currently working on our masters thesis and are seeking female high school varsity basketball teams to volunteer as participants in our study.

Research has revealed an increase in injury incidence to the female athlete. Many theories exist as to why this is occurring, yet little has been proven. There are several skeletal differences between males and females that have been theorized to be possible injury risk factors. However, these skeletal differences cannot be changed. We are instead looking at nutritional status, lean body weight, and menstrual status in relation to injury occurrence. If these factors do show a relationship with injury, coaches, athletic trainers, and health care workers may be better able to identify those athletes at greater risk for injury and take preventative measures to stop some injuries prior to occurrence.

We need female high school varsity basketball teams to volunteer to be a part of our study. Each volunteer will be asked to complete two surveys (a food frequency survey and a menstrual status survey). We will also weigh each volunteer and take a two site skinfold measurement. All testing will be performed at your or your daughter's individual high school along with the rest of your team. All data collected will be kept strictly confidential. The athlete's coach or athletic trainer will also be asked to keep an injury log throughout the regular season. This information will also be kept confidential.

If your daughter is willing to volunteer to participate in this study and you are willing to allow your daughter to participate please sign the attached consent form and return it to your coach prior to the assigned data collection date.

Thank you,

Megan Pavlak
Student Physical Therapist

Kristie Wood
Student Physical Therapist

Robyn Smith
Student Physical Therapist

APPENDIX I

FOOD FREQUENCY QUESTIONNAIRE PROCEDURE SCRIPT

Pass out survey.

"We ask that you please fill out this food frequency questionnaire completely and answer each question the best of your ability. Scores will be confidential and only your assigned number will be on the answer sheet."

"If you have questions during the survey please feel free to come ask me for clarification."

"The first column labeled sample food items identifies for you the types of food that particular question is asking you about. These are only guidelines and any other foods you consume which fall in this food category should also be counted. If you are not sure which category a particular food belongs in, please ask me."

"The second column labeled serving size is also just a guideline to help you accurately predict how much of each food category you consume in a typical week. I brought with me some samples of serving sizes to help you better visualize a serving as defined by this survey."

Hold up 1 oz of ready-to-eat cereal.

"This is 1 oz of ready-to-eat cereal."

Hold up ½ cup of canned fruit.

"This is ½ cup of canned fruit."

Hold up a 1 cup measuring cup.

"This is a 1 cup measuring cup to help visualize fluid amounts."

Hold up 3 oz of cooked meat.

"This is 3 oz of cooked meat."

Hold up 1 tablespoon of dressing.

"This is one tablespoon of dressing."

"One slice of processed cheese is approximately 2 ounces."

"One can of pop is 12 fluid ounces."

"The third column labeled number of servings per week is where you will give your answer. Your answer should reflect the number of servings you consume in a typical week. Please write the number in the column. If you have difficulty determining the number of servings you consume in one week, think about the number you typically eat per day and multiply by seven."

"When you have completed the questionnaire, please hand in to me."

"Please do not talk to your teammates while you are filling out the questionnaire."

"Are there any questions?"

"Begin."

APPENDIX J

MENSTRUAL STATUS QUESTIONNAIRE SCORING

1. If the athlete answers yes to question A she will be placed in the premenarchal category.

2. If the athlete checks box A for question number 2, she will be placed in the eumenorrheic category. If she checks box B, she will be placed in the oligomenorrheic category. If she checks box C, she will be placed in the amenorrheic category.

3. If the athlete answers yes to question 3, she will be placed in a contraceptive user category. The relationship between her menstrual status and her occurrence of injury will be considered on an individual basis since contraceptives can have an effect on menstrual status and on bone health. A "yes" answer to question 3 will not impact her nutritional category or her lean body weight statistics.

4. If the athlete answers yes to questions 4, 5, and/or 6, she will be placed in an "affected" category. The relationship between these athletes' menstrual status and their injury occurrences will not be examined because their menstrual status is altered due to their physiologic state. For example, a pregnant or nursing woman would not be expected to be menstruating although according to our survey she would be classified as amenorrheic.

APPENDIX K

CUMULATIVE DATA SHEET

Participant I.D.	School	Age	Height	Weight	Triceps	Subscap.	LBM	QD 1	QD 2

APPENDIX L

FOOD FREQUENCY QUESTIONNAIRE SCORING

Point Values for number of servings consumed per week

FOOD GROUPS	0	1	2	3	4	5	6	7	8	9	10
Grains	0-7	8-15	16-23	24-32	33-40	41-49	50-56	57-64	65-71	72-76	77+
Fruits	0-7	8-9	10	11-12	13	14	15	16-17	18-19	20	21+
Vegetables	0-7	8-9	10	11-12	13	14	15-18	19-21	22-25	26-27	28+
Lowfat Dairy	0-7	8-9	10	11-12	13	14	15	16-17	18-19	20	21+
Lowfat Meats	0	1	2-3	4-5	6	7	8-9	10-11	12	13	14+
High Fat Dairy	14+	12-13	10-11	8-9	6-7	5	4	3	2	xxx	0-1
High Fat Meats	14+	11-13	9-10	7-8	5-6	4	xxx	xxx	3	xxx	0-2
Fried Foods	7+	6	5	4	xxx	3	xxx	xxx	2	xxx	0-1
Extra Fats	21+	18-20	15-17	11-14	8-10	7	6	5	4	3	0-2
Cakes, Cookies	14+	12-13	10-11	8-9	6-7	5	xxx	4	3	xxx	0-2
Candy, Sugared Drinks	14+	12-13	10-11	8-9	6-7	5	xxx	4	3	xxx	0-2

APPENDIX M

MENSTRUAL QUESTIONNAIRE SCRIPT

Hand out questionnaire

"Here is questionnaire about your menstrual periods and related questions. Please answer all questions to the best of your ability. You may ask questions at any time while you are filling it out. Please use only your identification number when filling out the questionnaire. Do not put your name anywhere on it. All answers to this questionnaire will be kept strictly confidential. Please hand the survey to me when you are finished." Please do not talk to your teammates during this survey."