UNIVERSITY OF WISCONSIN – LA CROSSE

Graduate Studies

# THE PREVALENCE OF THE COMPONENTS OF THE FEMALE ATHLETE TRIAD IN COLLEGE AGED FEMALES

A Manuscript Style Thesis Submitted in Partial Fulfillment of the Requirements for the

Degree of Master of Science in Clinical Exercise Physiology

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PREVALENCE OF THE COMPONENTS OF THE FEMALE ATHLETE TRIAD IN COLLEGE AGED FEMALES

By Jessica K. Davis

We recommend acceptance of this thesis in partial fulfillment of the candidate's requirements for the degree of the Master of Science in Clinical Exercise Physiology.

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**ABSTRACT**


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The purpose of this study was to observe if any component or combination of components of the Female Athlete Triad existed in active college aged females. Thirty-five college aged females who were moderately active and not using any oral contraceptives participated in this study. All participants recorded their physical activity for three days and nutrient intake for 24 hours in order to obtain energy expenditure and intake. In addition, questions concerning their menstrual cycle history were also asked. Finally, a DEXA scan was used to obtain bone mineral density and body composition. Frequencies of each component of the triad were tallied and showed none of the participants met the criteria for all three of the components. Only one participant showed signs for low energy availability and irregular menstrual cycles. In addition, no other combination of the components existed. Overall, our results do not suggest that physically active college aged females are at risk for the Female Athlete Triad.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF APPENDICES

# INTRODUCTION

It is important to be physically active for health and fitness purposes. However, position stands have indicated there are some medical conditions specific to women and girls who are physically active. The Female Athlete Triad is one of those medical conditions. It is a syndrome that consists of three components; 1) low energy availability; 2) menstrual cycle abnormalities; and 3) low bone mineral density. In all of the American College of Sports Medicine's position stands concerning the Triad, it was stated that all physically active girls and women may be at risk for developing the female athlete triad or any one of its components (10, 14). The medical concern with the triad is that it can negatively affect physical health and lead to morbidity and mortality in active females. However, much controversy exists over the promotion of the triad. While the components of the triad are major health risks, some suggest the publication and promotion of the triad may actually discourage physical activity in females.

The three interrelated conditions of the triad make it complicated to understand. It has been suggested that low energy availability leads to menstrual dysfunction, which leads to low bone mineral density. The most recent position stand suggests energy availability falls on a continuum ranging from most severe (e.g., bulimia and anorexia) to least severe (e.g., harmful eating behaviors and excessive exercise). The continuum illustrates how those that are at the least severe range and begin to have harmful eating behaviors, may eventually place themselves at risk for the most severe or clinical diagnosis of eating disorders.

Low energy availability (i.e., < 30 kcal/kg/LBM per day) is defined as energy expenditure higher than dietary energy intake, which results in energy deficiency. Energy availability is the amount of dietary energy remaining after exercise training for other metabolic processes (5, 7). Some health concerns that arise from low energy availability range from psychological to medical problems. Psychological problems include low self-esteem, depression, and anxiety disorders. Medical problems include disorders of cardiovascular, endocrine, gastrointestinal, renal, central nervous system, skeletal and reproductive function (9). The Triad focuses on menstrual dysfunction and low bone mineral density. The issue with low energy availability is that the body must compensate for these low levels of energy by disrupting the reproductive system and bone metabolism (3, 5, 16).

Energy is necessary for the regulation of the hormones involved in the menstrual cycle. When energy levels are low, one of the body's responses is to shut down the reproductive system in order to survive (17). Menstrual dysfunction is affected by the pulsatile secretion of luteinizing hormone (LH) from the pituitary, which is disrupted by pulsatile secretion of gonadotropin-release hormone (GnRH). When (LH) is abnormal or low it disrupts ovarian function which, can lead to a suppression of the menstrual cycles (7, 9). The main function of (LH) is to help regulate ovulation, which is necessary for fertility. If (LH) is not stimulated it can cause the secretion of estrogen to decrease which, disrupts the formation of bone (10,15). A women's energy availability is very variable but a disturbance in the menstrual cycle is not as evident.

Menstrual functions are defined as eumenorrhic (normal) to oligomenorrhic (irregular cycles) to amenorrhic (lack of menstrual cycle for greater than three consecutive months) (10). Women who are amenorrhic suppress ovarian follicular development, ovulations, and luteal function (10). A lack of menstrual cycles results in low estrogen levels, which can negatively impact bone health by increasing bone resorption. (10). With irregular menstrual cycles come other concerns such as infertility, development of stress fractures, and decreases in bone mineral content. With every menstrual cycle that is missed, bone mineral density may be effected (10). This alteration to the menstrual cycle then leads to the third component of the triad, low bone mineral density.

Bone mineral density (BMD) is a medical concern as low bone mineral density can lead to osteoporosis. The concern with osteoporosis is the decrease in bone strength and increase risk for stress fractures. Osteoporosis is defined as BMD more than 2.5 SD below the mean of young adults established by the World Health Organization (2). The rate of developing a fracture nearly doubles for each reduction in one standard deviation in BMD (9, 10). Bone mineral density can be affected by either menstrual dysfunction and or inadequate diet (17, 18). When energy availability is reduced there are fewer micronutrients and macronutrients, which are essential for bone formation. When bone resorption is greater than bone formation the result can lead to stress fractures or osteoporosis (11). When a female's menstrual cycle is normal and there is an efficient amount of estrogen, bone metabolism is properly maintained (3, 10). The importance of regular menstrual cycles is obtaining optimal bone health.

Since the first position stand (1992), there has been much controversy over the existence of the triad. While the triad does present women and girls with severe health risks, the opponents to the triad feel this statement may inhibit girls and women from participating in physical activity because it may cause serious health risks. In a society today where obesity and overweight are growing exponentially, it becomes critical to really understand any health risks that may be associated with activity that would prevent people from being active. Additionally, the triad was originally suggested for female athletes. It was in the 1997 Position Stand (14) where the statement was made that all physically active women and girls are at risk. Nonetheless, the majority of the data has been done on elite level athletes and very little has looked at the triad in a normal active population. Very little information has been presented for the active female in terms of actual prevalence of the triad or any of its components. Therefore, the purpose of this study was to determine if the female athlete triad or any of its components exist in physically active college aged women.

## METHODS

### Participants

Thirty-five physically active college aged females (19-25 years old) were recruited for this study. In order to more completely understand the impact of low energy availability on the menstrual cycle, only those not using hormonal contraceptives were allowed to participate in this study. Additionally, we restricted the sample to those who were physically active which was defined as participating in at least 30 minutes of aerobic activity for three to five days a week. A pre-screening evaluation based on physical activity level and contraceptive usage was conducted in order to find appropriate candidates.  All participants provided written informed consent prior to any testing.  All forms were approved by the University of Wisconsin – La Crosse Institutional Review Board.

**Procedures**

A total of 51 females initially filled out the surveys, however only 35 females met our guidelines.  Each participant that met our pre-screening guidelines was instructed to keep a 24 hour dietary food journal, which was to be filled out the day before their testing session.  They were also instructed to log their physical activity during the week of their testing session.  Information on the participant's involvement in high school sports and injuries they acquired were also surveyed Table 1.

Table 1: Participants background.

[redacted]

Participants were provided with instructions on how to fill out the three day physical activity log and 24 hour dietary recall.  Physical activity logs were to include two weekdays of physical activity and one weekend day.  The physical activity logs asked type, the duration, and the intensity of their exercise. Intensity was self-reported and measure as light, medium or heavy exercise.  The day before arrival for their testing session, participants were asked to fill out a 24 hour dietary recall.  This record consisted of recording all the foods, beverages, and supplements ingested on a sample form.  In addition, testing times were also set up to visit the Human Performance Lab for a total body scan and completion of the nutrition and menstrual cycle interview. These individual sessions lasted about 30 minutes per participant.

Upon arrival to the lab, participants were interviewed on their dietary recall using food models and questioning to obtain accurate information. Once dietary information was obtained, the data was then entered into an ESHA Food Processor to analyze each participant's nutritional intake. To get an estimate of energy requirements, the participant's height (cm), weight (kg) were measured and date of birth and physical activity status was asked. Each participant was described how active (e.g., light, moderate, or highly active) they were for the same day the diet recall occurred in order for activity level to be entered into the software program. In addition, in order to accurately obtain energy expenditure, each participant was questioned in more detail about physical activity log. Calculations for energy expenditure were done by averaging their activity on the two weekdays in order to estimate energy availability.

In order to determine low energy availability, energy intake, energy expenditure, and lean body mass were needed. Their total dietary energy intake was taken from the ESHA Food Processor analysis. Energy expended was calculated by averaging their two weekday exercises. Low energy availability was calculated (energy intake – energy expended / lean body mass.) Lean body mass was obtained by Dual X-ray Absortiometry (3, 9).

In addition, a total body scan using the Dual X-ray Absorptiometry (DEXA) (Lunar, DPXL/PED, Wisconsin, USA) was then performed to obtain total bone mineral density (BMD), bone mineral content (BMC), percent body fat, fat mass (FM), and lean body mass (LBM). The DEXA was checked each day of testing for normal ranges and all DEXA scans were performed by a certified technician. Outcomes included total BMD and Z-scores for those participants who were 20 years of age. For those under 20 years old Z-score were not provided, calculations had to be made (raw BMD- mean BMD)/SD. The mean BMD was obtained from Van der Sluis et al. (22).

The second portion of the testing session consisted of menstrual cycle regularity. Each participant was again, interviewed about their menstrual cycle history. Questions were based on the history and regularity of their cycles. Regularity was reported as being regular, slightly irregular, or very irregular and if activity or dietary habits affected their cycles. Questionnaires can be found in Appendix C.

### Analysis

Descriptive statistics were performed on each variable critical to the triad which included, lean body mass, bone mineral density, and caloric intake. The following criteria were used to determine prevalence of the triad or its components: low energy availability less than 30 kcal·kg·LBM·day, self reported irregular menstrual cycles greater than a 10 day variation between cycles, and bone mineral density reported as a Z score of less than 1.5. Frequencies were counted as to how many participants met the individual criteria for the female athlete triad and results were reported as a percent.

## RESULTS

Thirty-five active females aged 20.8 ± 1.6 years participated in this study. Descriptive statistics for all variables measured for the total sample are found in Table 2.

Table 2: Descriptive Statistics of Subjects.

[redacted]

Background information revealed the majority (94.3%) of the participants were involved in high school sports and only four reported having any type of skeletal related injury Table 1. Of those four with skeletal injuries only one showed negative Z score for BMD.

Beginning with the nutritional components, the majority (88.57%) of the participants had low caloric intake (<2700 kcal) and (82.57%) didn't meet the recommended 37 kcal/kg for moderate activity level (8). When estimating low energy availability, only 13 participants (37.1%) met the criteria (6). Only two (5.71%) participants had ever used any pathogenic weight control method. In addition, means and standard deviations were reported for other critical macronutrients and micronutrients and results are found in Table 2.

Menstrual cycle irregularity was only reported in four (11.42%) participants, even though 13 (37.1%) had low energy availability. Of those 13 who had low energy availability, only one self reported an irregular cycle. Nonetheless, 19 (54.30 %) of the participants reported regular menstrual cycles meaning each cycle length was within three days of when it was expected Table 3. Questions regarding overall menstrual cycle history found only 10 (28.6%) reported missing their menstrual cycle for at least two consecutive months since age of menarche. The DEXA results did not show any of the females to have under Z-score of -1.5.

Table 3: Menstrual Cycle Frequency Distribution.

[redacted]

Considering it has been suggested that low energy availability is the precursor to menstrual cycle irregularities and irregular cycles can lead to decrease bone mineral density, we analyzed each component of the triad beginning with low energy availability Table 4. Out of the 35 participants 37.1% (14) showed signs of low energy availability and out of those 13 only one reported irregular menstrual cycles. Additionally, none of the participants with low energy availability and/or irregular menstrual cycles had a low BMD (Z-score < 1.5). However, three of those with low energy availability had low BMD with a Z-score less than zero.

Table 4: Female Athlete Triad Prevalence among 35 participants.

[redacted]

When each of the components was analyzed separately, frequencies were much larger. For example, results showed that 31 (88.57%) of the participants didn't meet the recommended daily kilocalories per day while 29 (82.86%) didn't meet recommended kilocalories per kilogram body weight. Of all the participants who showed signs of low energy availability only 2 (5.71%) had ever used pathogenic weight control method in the past. Overall, there was only four (11.43%) who has irregular menstrual cycles and zero who had bone issues.

## DISCUSSION

Overall, the study did not find any participant with all components of the Female Athlete Triad in this sample of physically active college aged females. In fact, our results showed that even though the majority of the females had a significantly low dietary intake and low energy availability, it did not seem to impact either menstrual cycle or bone mineral density. This study was similar to Burrows et al. (1) who suggest that not all women are at risk for the triad.

It has been considered that low energy availability is the primary precursor to the development of the triad. With or without knowing it, females sometimes reduce their energy availability by either decreasing energy intake or increasing energy expenditure. This decreased energy availability is a concern because any active female with less than 30 kcal·kg·LBW·day can show a suppressed luteinizing pulse frequency (6). If LH is suppressed it can prevent ovulation from taking place. As a result, this can increase the risk of developing amenorrhea. Our results showed that 37.10% of the participants had low energy availability. However, we also found only one of those who had low energy availability had self reported irregular menstrual cycles. This result is much lower compared with other studies. Torstveit and Sundgot-Borgen (17), found 13.8% of their controls to have had both clinical eating disorders and menstrual dysfunctions. They described their controls as physically active females who trained an average of 5.3 ± 5.3 hours per week. Two other studies showed that those who had irregular menstrual cycles also had significantly lower energy intakes (13, 16). Nelson et al. (13) found that on average the amenorrheic women reported to have a lower energy availability compared to the eumenorrheic subjects. Considering a clinical eating disorder would fall on the most severe end of the spectrum continuum and inadequate energy balance for whatever reason would be the least severe, and according to the 2007 ACSM Position Stand, our results should have shown a much higher combination of low energy availability and menstrual dysfunction. In addition, Torstveit and Sundgot-Borgen (17), suggested the use of pathogenic weight control methods being a potential trigger to triad components. Again, our results showed much smaller frequencies (5.71%) of those with pathogenic weight control methods. The concern with women using pathogenic weight control methods is compounded when they are physically active. Agreeably, this is a problem in females, as our study found that of the two participants, who reported using these methods, had low energy availability but only had one self-reported irregular menstrual cycle. While this is most certainly a concern, it begs for more research into the length of time it may take to see impacts of dieting behavior on menstrual cycle disturbances and the link to the further development of the triad.

The ACSM Position Stand (10) also suggests that low energy availability can impact bone health. A decrease in energy availability may result in not meeting the recommended nutritional value that is needed for optimal health. Important nutritional factors such as calcium and vitamin D may be depleted due to the reduction in caloric intake. Torstveit and Sundgot-Borgen (17) found 15.2% of their controls to have the combination of disordered eating and low BMD. Burrows et al., (1) also found a significant lower BMD in the femoral neck of the disordered eating group compared to non-disordered eating group. However, when comparing the two groups at the lumbar spine there was no significant difference. Our results had no participants that had low energy availability to have a low BMD. In fact, none of the participants showed signs of low BMD Z-score -2.5 SD. Although we didn't see anyone with a BMD <1.5 SD; 10 participants showed signs of negative BMD < 0 SD. Out of those 10 only three had low energy availability. However, perhaps the impact of bone doesn't show up after some time. Nonetheless, to our knowledge no studies following the long term affects of low energy availability and bone mineral density have been performed

Bone health is also dependent on the mineral density and bone mass. This is critical, especially in active women as a stronger bone has a reduced risk of fracturing.

Along with proper nutrition, estrogen and weight bearing activities have a positive impact on bone strength. In addition, bone density is accrued during the teenage years, specifically post-pubertal years. Activity during this key time frame can lead to a positive impact on bone strength. We found this to be true in our sample as 94.3% of our participants participated in high school sports suggesting sports participation may lead to an overall healthy BMD. This is supported by other studies that have shown females who participate in sports and are physically active tend to have higher BMD (17, 18, 20).

When occurring along or in combination with low energy availability and menstrual dysfunction can affect bone formation. Another factor that influences BMD is estrogen. Estrogen helps decelerate the loss of bone by slowing down bone resportion and osteoclast activity (12). When a female becomes amerorrheic, estrogen is no longer available to positively affect bone formation. Torstviet and Sundgot-Borgen (17), found 12.4% of their controls who had reported menstrual dysfunction also had low BMD. Menstrual dysfunction was defined as primary & secondary amenorrhea, oligoamenorrhea, and short luteal phase. Low BMD was reported when one of five sites measured showed a Z-score between -1.0 and -2.0. This is a limitation to our study as we only estimated total bone mineral density and not site specific. Our study found 11.42% who reported irregular menstrual cycles, however none of them had low BMD (Z score < 2.5). However, Nelson et al., (13), showed no difference in BMD of the radius shaft between their amenorrheic and eumenorrheic women, but did find a difference in the lumbar vertebrae. Although none of them showed signs of osteoporosis there were ten participants who showed negative Z-score <0 and of those ten, only one fell between -1.0 and -2.0 range. Furthermore, it is uncertain what the long term affects on BMD will be for those women and it may be helpful to obtain future Z-scores of those who showed negative scores. The 2007 ACSM Position Stand is lacking evidence on how these three components which are interrelated really affect physically active females.

There were several limitations inherent in this study. First, we only performed a 24 hour dietary recall instead of a three or seven day recall and as a result the accuracy of energy intake is decreased. While we do acknowledge this factor, some of our participants listed as having low energy availability may not have been. On the other hand, this shorter dietary recall made the compliance of the subjects a lot higher versus a three day recall.

Second, we asked all participants to record their physical activity recall over a three day period in order to estimate energy expenditure. While we feel two weekdays can well represent overall activity level, the participants may have over reported their physical activity. Again, as a result, this over reporting could have effected our calculation of energy availability and resulted in an overestimation.

Third, we relied on self reporting of menstrual cycle disruption and history. In order to truly determine the impact of the menstrual cycle, a hormone analysis would be ideal. In retrospect, while hormone analysis is more accurate, other studies (17, 18) have used surveys for interpreting menstrual dysfunction.

Lastly, while we used a DEXA to determine bone mineral density and determine an appropriate Z-score in order to make comparisons, our DEXA only provides Z scores for participants over the age of 19 years. Therefore, we used the participant's raw total body BMD – 1.177 / 0.09 (22). Nonetheless, it is important to keep in mind both these numbers were used on the same DEXA (Lunar, DPXL/PED, Wisconsin, USA) machine.

Overall, our study did not find the female athlete triad to exist in a sample of active college aged females. Additionally, we only found that 13 had at least one component, and one had at least two components. The ACSM Position Stand states that all physically active girls may be at risk for developing components of the triad along or in combination. However we did not see a high frequency of these combinations among our participants. However for future thought we did see some signs that could eventually affect ones overall health, but more information is needed. We are unsure as to what impact do these components have on quality of life and how long a female has to have one of these components to get another. Future research should look at how these components may affect each other over time.

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APPENDIX A
INFORMED CONSENT

**Department of Exercise and Sport Science - Human Performance Laboratory**
**Informed Consent**

## Title: Bone Density and Body Composition in Collegiate Female Athletes

I have been informed that the purpose of this study is to understand the influence of training on bone density and body composition. The components of this project include information concerning my body composition, bone mineral density, menstrual cycle history, and dietary history. Training information as well as performance measures will be obtained from my coach throughout the season.

I have been informed there are 3 testing sessions that will all take place in the Human Performance Laboratory (225 Mitchell Hall). Each session should last approximately 45 minutes. The 3 sessions are spread out during the season and include pre-season (August), mid-season (September), and post-season (October). On the test day, questionnaires concerning my menstrual cycle and diet will be given by Dottie Boyce, Investigator and Becki Battista, Ph.D. Dr. Battista will be present to answer questions I may have regarding the questionnaires. Once all questionnaires are completed, skeletal breadths will be determined. Skeletal breadths include measuring bony landmarks across the shoulders, hips, knee, and elbow.

At each visit body composition (relative amounts of fat and lean tissue) and bone density will be determined by using an FDA-approved bone density machine (Prodigy, GE Lunar Corp., Madison, WI). The procedure is called Dual Energy X-ray Absorptiometry (DEXA). For this procedure, I will be asked to lie face up, on a padded table for 7 minutes while the scanner arm of the DEXA machine passes over my entire body. The scanner will not enclose me or touch me, and I can wear my regular clothing (no metal allowed). A person trained for the use of the DEXA will perform all testing.

I have been informed that I will be exposed to minimal radiation (1-4 microSieverts) that is within an acceptable range as provided by the Wisconsin Department of Health and Family Services (DHFS) [Chapter HSS 157.23(1)]. Any time an individual is exposed to radiation there is potential risk. The amount of radiation (1-4 microSieverts) that I would be exposed to is quite minimal. For example, I would receive radiation exposure of approximately 80 microSieverts on a transatlantic airline flight of 8 hours, 50 microSieverts living in Denver, Colorado, at an elevation of 5,000 feet for approximately 4 weeks, or 30 to 40 microSieverts during a typical chest x-ray.

I have been informed that females with ANY chance of being pregnant should not undergo DEXA scanning. If I become pregnant during the course of a study that includes DEXA scanning, I will immediately inform the staff, and withdraw from the investigation.

I have been informed that during the week of my DEXA testing session I will record, for 1 day, all of the food and beverages I consume during that 24 hour period. I will be provided with data sheets in which to record my caloric intake. After the 24 hour period I will visit the Physiology Laboratory at the Health Science Center for an interview with the investigator, Dottie Boyce. The interview will last approximately 20 minutes during which time the investigator will ask me questions concerning the food and drink I consumed the day before. I have been informed I will do these nutritional inventories 3 times throughout the season (during the same time frame as the body composition/bone density testing).

In the unlikely event that any injury or illness occurs as a result of this research, the Board of Regents of the University of Wisconsin System, and the University of Wisconsin-La Crosse, their officers, agents, and employees, do not automatically provide reimbursement for medical care or other compensation. Payment for treatment of any injury or illness must be provided by me or my third-party payor, such as my health insurer or Medicare. If any injury or illness occurs in the course of research, or for more information, I will notify the investigator in charge. I have been informed that I am not waiving any rights that I may have for injury resulting from negligence of any person or the institution.

I have been informed that the total time for the test procedures will be approximately 1 hour. As a result of the tests I will possess an accurate measure of my body composition as determined by DEXA. In addition, I will have the measurements concerning bone mineral density. I have been informed that this study is a longitudinal study, and testing will continue throughout the 4 years I am a student-athlete at the University of Wisconsin – La Crosse. The findings of this study may be published in scientific literature or presented at professional meetings using group data only. There is no cost to me for participating in this study and I am free to withdraw from the study at any time without penalty.

Questions regarding study procedures may be directed to Dr. Becki Battista, Department of Exercise and Sport Science (608-785-8685), Dottie Boyce, Principle Investigator (boyce.doro@students.uwlax.edu), Dr. Carl Foster, Director of the Human Performance Laboratory (608-785-8687), or Chris Dodge, Human Performance Laboratory Manager (608-785-8685). Questions regarding the protection of human subjects may be addressed to Dr. Bart Van Voorhis, Chair of the Institutional Review Board for the Protection of Human Subjects, (608-785-6892).

| | |
|---|---|
| ______________________________ | ____________________ |
| Participant | Date |
| ______________________________ | ____________________ |
| Principle Investigator | Date |

# APPENDIX B
# EATING BEHAVIOR JOURNAL

# Eating Behavior Journal

Name: ____________________

Day/Date: ____________________ Physical Activities:[1] ____________________

| Time | Location/ Place | Foods and Beverages Consumed Amounts/Description | Degree of Hunger[2] | Social Situation[3] | Comments[4] |
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[1]Include type of activities and minutes engaged in the activities
[2]Use the following rating scale: 0 = not hungry; 1 = hungry; 2 = very hungry
[3] Indicate activities and who your were with, if anyone
[4] Record significant thoughts ("I'm doing great", "I am a loser"); feelings (angry, happy, worried); concerns ("Maybe I should have had the turkey sandwich")

# APPENDIX C
# MENSTRUAL CYCLE HISTORY QUESTIONNAIRE

**Menstrual Cycle History Questionnaire**

Subject: ________________________________

Height: _________ Weight: _________

Date of Birth: __________________ Age of Menarche: ____________________

1. How many days has it been since your last menstrual cycle? _____________
2. How many menstrual cycles have you had in the last 12 months? __________
3. How many days do you normally have between your cycles? _____________
4. Use your response to question #2 to determine the regularity of your cycle:

   ______ I am very regular (within 3 days)

   ______ I am somewhat irregular (4 – 10 day variation)

   ______ I am very irregular (variation > 10 days)

5. Do your periods change with changes in your training regimen?

   ______ yes ______ no

6. Do your periods change with changes in your weight?

   ______ yes ______ no

7. Do your periods change with changes in your diet?

   ______ yes ______ no

8. Have you ever gone more than 2 months without having a menstrual period?

   ______ yes ______ no

   If yes, how old were you when you first missed > 2 periods? _______

   How long did you go without menstruating (months)? ________

   Did you see a Physician? ______ yes ______no

   If yes, what was/were the diagnosis and treatment? ____________________

9. Do you currently take birth control pills or hormones? ______yes ______no

   If yes, describe the type and length of use:

   ______________________________

10. Please briefly describe any other menstrual irregularities or problems not already covered in the above questions.
11. Have you ever used any pathogenic weight control methods (diet pills, hunger repressive pills, laxatives, diuretics, or vomiting)? ______ yes ______no
12. If yes, did this occur during this semester? ______ yes ______no

APPENDIX D
LITERATURE REVIEW

# INTRODUCTION

Participation in physical activity has major physical and mental health benefits. However, women and girls that are physically active should be aware of some risk associated with being active. The female athlete triad consists of low energy availability and its relationship to menstrual cycle disruptions and osteoporosis. The most recent position stand from the American College of Sports Medicine (2007) has stated all physically active girls and women are at risk for the triad. Nonetheless, there is mixed evidence actually supporting this idea. It has been stated that the definition of the Triad is too broad, placing females at "risk" who really may not be (3).

Although, the name 'female athlete triad' implies that athletes are the ones at risk, it has shown that any physically active girl or woman has the possibility of developing components of the syndrome (10, 15). The three components involved are low energy availability, menstrual dysfunction, and low bone mineral density. Recently it has been suggested that these components fall along a spectrum ranging from optimal health to disease state (10, 11). Nonetheless, it is important to understand the interconnected relationship these components share. While some believe the triad to be a real concern to physically active women, others believe this may entice women to not exercise (3). As a result it is important to acknowledge the suggested short and long term health consequences associated with the triad.

Females tend to be more at risk as there are twice as many females then males who consider themselves as overweight and an increased amount who are actively trying to lose weight (5). Having weight issues usually results in altering energy, whether it is intake or expenditure. A decrease in energy availability may be due to overexerting without adequate energy intake or possibly disordered eating behaviors. Most commonly, low energy availability results in a reduction of dietary intake and an increase in energy expenditure (12). In females, excessive low energy availability can impair reproductive and skeletal health. Physically active girls and women that have low energy availability may even have a higher risk for low bone mineral density than athletes (11). Tortsviet et al. (15) compared the prevalence of the Triad in both athletes and controls. A control subject was defined as participating in 5.3 hours per week of physical activity. Approximately 300 elite athletes and 300 non-athletes were asked to participate in this project, however only they ended with 186 athletes and 145 controls. The study was carried out in three phases; Phase I questioned them on their physical activity level, menstrual cycles/contraceptive use, weight, dietary patterns, and eating disorder behaviors; Phase II measured a sub-sample of the two groups for bone mineral density; and Phase III was a clinical interview to determine if any were at risk of clinical eating disorders. Results showed a higher link between disordered eating/ eating disorders and menstrual dysfunctions in athletes while the controls had a higher link between menstrual dysfunction and lower bone mineral density (15). Nonetheless, it was concluded that components of the triad can be present in both elite athletes and non-athletes (11, 15). This, however, is not consistent across all studies. Burrow et al. (2007) studied 82 sports club recruited participants and found none to have reported all three of the components. However, they did explain that 55% of the participants were labeled "at risk" for future progression of the Triad. This suggests the need to focus also on the long term affects. Nonetheless, it is important to fully understand all components of the triad and their inter-relationships and potential consequences.

## ENERGY AVAILABILITY/ DISORDERED EATING

The concern with females developing any or all of the triad is not only the performance of the athlete but also to her overall health risk. This risk is what has spurred much debate in the recent literature. Although the Female Athlete Triad focuses on athletes, particularly ones in leanness type sports, it has been suggested that all physically active women and girls are also at risk. This risk may not necessarily be a result of the activity but of the events associated with the activity.

On the spectrum suggested by the 2007 ACSM Position Stand, energy availability ranges from optimal energy availability, to low energy availability, to eating disorders. Low energy availability is defined as energy expenditure being higher then dietary energy intake, which results in energy deficiency (5, 6). For example, many females receive pressures about dieting from society. These pressures are social, psychological, and physiologic, and may lead to caloric deficits (12, 18). For many recreational women, dieting or excessive exercising may be a normal starting point. The most recent literature states that excess activity may lead to caloric deficits and result in menstrual cycle disruption (8). For many years, the disordered eating was the terminology used, however it is now replaced with low energy availability. The most recent Position Stand (10) restates the importance of energy balance in active females as being the most critical component. Although all the three components are interlaced it is suggested that low energy availability is the main cause.

Energy availability ranges from optimal energy availability, to low energy availability, to eating disorders. Low energy availability is defined as energy expenditure being higher then dietary energy intake, which results in energy deficiency (5, 6, 10).

Practices of energy deficiency range from over exercising with inadequate calories intake, to abnormal eating behaviors. A female may become energy deficient because she intentionally wants to lose weight or it may just be done inadvertently due to increase in training and suppression of hunger (5, 13). Abnormal eating behaviors range from clinical disorders to eating disorders not otherwise specified (10, 19). Clinical eating disorders along with reported use of pathogenic weight control methods just may be more prominent in physically active females compared to athletes (3). This leads us to believe that physically active females concerned with their body, eating habits, and weight may be at risk for developing the triad.

Reinking and Alexander, (12) studied the prevalence of disordered-eating behaviors in female athletes and non-athletes. They compared 84 collegiate athletes and 62 non-athletes. Each participant completed questionnaires assessing their symptoms associated with eating disorders, weight, and menstrual function. Their results did not show athletes to have more disordered eating symptoms than non-athletic woman. It also showed that the female athletes had an overall better body satisfaction compared to non-athletes. Therefore, the authors concluded that athletes are not the population who are concerned with their weight and what they eat. If physically active females are also concerned with energy intake could this lead them to developing the triad as well?

## ENERGY AVAILABILITY/ MENSTRUAL DYSFUNCTION

Menstrual dysfunction is a second component of the triad. Menstrual functions range from being eumenorrhea (regular menstrual cycles), to oligomenorrhea (menstrual cycle intervals longer than 35 days), to amenorrhea. Primary amenorrhea is defined as a delay in the age of menarche, and secondary amenorrhea is an absence of menstrual cycles for three or more consecutive months (10). Although, each component can occur alone, it appears that low energy availability may be the main factor for menstrual dysfunction in exercising girls and women (2, 10, 16, 17). Until recently, many believed that the factor of menstrual dysfunction was due to low body weight and low body fat.

The etiology of irregular menstrual functions is caused by a malfunction at the hypothalamic level (16). The main hormone affected is the gonadotropin- releasing hormone (GnRH). This disruption of GnRH suppresses the luteinizing hormone (LH). Low GnRH's and estrogen levels have been shown to be affected by low energy availability/ disordered eating (Warren, 1999). Low energy availability slows the secretion of GnRH, which lowers LH and a low LH reduces the secretion of estrogen to the ovaries (3, 9, 13). In addition, Loucks et al., (8) found that the luteinizing hormone pulsatility is disrupted in females with lower energy availability and not suppressed by stress of exercise.

Amenorrhea is the lack of a menstrual cycle for three consecutive months. Amenorrhea is generally induced by multiple small changes in pulsality of LH and FSH secretion that later progresses to a chronic problem that eventually stops menses all together (17). The most recent evidence suggests luteinizing hormone is disrupted when females reduce their energy availability to more than 33%, thus suggesting energy availability was lower than 30 kcal/kg LBM·day (7). This energy deficiency might place physically active females at risk for ovarian dysfunction and becoming amenorrheic.

Studies have suggested the chief cause of menstrual dysfunction is a negative energy balance (7, 9, 18). Williams et al., (19) used animal models to investigate the effect of low energy availability on menstrual dysfunctions providing evidence that an increase in energy expenditure combined with low energy availability resulted in exercise induced amenorrhea. This study supports the findings that low energy availability and an increase in exercise can trigger exercise-induced amenorrhea rather than exercise associated factors such as physical or psychological stress (19). Loucks and Thuma (7) observed young, healthy, regular menstruating women and found when energy availability was below 30 kcal/kg/LBM/day, LH pulsatility was disrupted. When the LH is disrupted it places women at greater risk for stress fracture due to the low levels of estrogen in the body (7).

Our body's way of protecting itself during periods of low energy availability is to compromise the reproduction mechanisms. Tomten and Hostmark (14), observed 10 runners with regular menstrual cycles and 10 with irregular menstrual cycles with similar running patterns. Participants were Caucasian females ages 17-40 years who were recruited though a running competition. They were interviewed on their nutritional and weight concerns and awareness. Additionally, none of the 20 runners experienced disordered-eating patterns at the time of the study. They took blood samples of the runner's follicle-stimulating hormone, thyrotropin and estradiol, luteinizing hormone, free thyroxine, and cortisol to analyze their menstrual cycles. Results showed that although both groups ate a well-composed diet, the irregular group had a slightly lower dietary energy intake then the regular group. This suggests that low energy availability can lead to irregular menstrual cycles.   Which could eventually compromise reproductive and growth function in females with low energy availability?

**BONE**

Osteoporosis is the third component of the triad.  Bone mineral density (BMD) is very adaptable and can be affected by poor nutrition and/or varying levels of hormones. Throughout life, bone goes through a remodeling process which is affected by three factors, hormonal status, weight-bearing activity, and dietary intake (12).  The most severe consequence of porous bones is osteoporosis.  Osteoporosis is a "skeletal disorder characterized by compromised bone strength predisposing a person a person to an increased risk of a fracture" (11) and  is defined as a bone mineral density Z score of less than 2.5 SD (5).

The position stand suggests that all physically active girls and women are at risk for the triad, which includes low bone mineral density.  However, we also know physical activity is a stimulus to bone.  So how is bone mineral density affected in athletes or active females?  Torstveit and Sundgot-Borgen (15) used athlete and non-athlete controls to compare BMD.  The study compared BMD in 186 athletes and 145 non-athletic controls and found that athletes had an overall higher BMD score compared to non-athletes illustrating the positive effect of athletic participation on bone health.  To determine if similar findings occur in an active population, controls were randomly selected female citizens from Norway none of which participated in a sport.  Physical activity was defined as total hours per week and calculated as weight bearing and non-weight bearing activities.  Twenty-eight percent of the controls had a low BMD in one of the five sites compared to 11% of the athletes.  These results do illustrate that physically active females can have some bone related disorders and as a result, suffer from one component in the triad.

Low BMD is a health concern as it is often a precursor to stress fractures or even worse, osteoporosis. The risk for fractures nearly doubles for every reduction of one standard deviation in BMD (6). In addition, the risk of osteoporosis significantly increases when diagnosed with low BMD < 2.5 SD. Even though exercise can increase BMD, it can be negatively tempered if females have poor nutritional habits and altered hormonal status (10, 12). For example, BMD declines as the number of missed menstrual cycles increases. In fact, lBMD can decrease by as much as 30% if the number of missed cycles is beyond 40. This places any female who may be amenorrohic, at a higher risk for stress fractures.

Bone mineral density ranges on the spectrum from optimal bone health to low BMD to osteoporosis. Meaning, if a female falls anywhere along this spectrum she could potentially be at risk for the long term health consequences. Osteoporosis, which may be an irreversible disease, can also lead females to an increase risk of stress fractures. It is important to understand that early identification if helpful to stop the progression of bone absorption. The key factor here is the other two components, low energy availability and menstrual dysfunctions are reversible while osteoporosis may not be.

A combination of exercise intensity, duration, and frequency can help to decrease the risk of low BMD (12). Ford et al., (4) found that females who were not active in high school were seven times more likely to have low BMD. They also showed that participation in high school sports positively affected BMD suggesting that females who continue to be active later in life could possibility prevent low BMD and its negative impact. This study found that being physically active is a positive factor to bone health.

## SUMMARY

Due to the broad classification of the triad many suggest that both athletes and physically active females are at risk (11, 16). Few studies show a very high prevalence of all three components (3). In addition, while many studies publicize the number of females at risk for the triad they often use varying definitions of the components making it more difficult to understand the proposed consequences. While the 2007 Position Stand states that all physically active females are at risk others suggest that not all physically active females are at risk but are at risk for future health problems. Unfortunately we do not know the long term health effects of the triad. Nonetheless, this makes it critical to more fully understand the actual prevalence of the triad and its potential long term consequences in order to ask the question, do all physically active females need to be concerned with these risk factors?

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