THE FEMALE ATHLETE TRIAD: A COMPARISON OF COMPETITIVE AND NON-COMPETITIVE RUNNERS AND SWIMMERS

by

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INTRODUCTION

Most people believe that being physically active automatically correlates with improved health status, both in the physical and psychological realms. Involvement in sports and recreation does in fact come with many health benefits; however, as more females become competitive and focused on performance, the goal of exercise shifts from weight management and enjoyment to weight loss and outperforming everyone. For this reason, there has been an increased awareness of the female athlete triad (F.A.T.) which was first termed at the Triad Consensus Conference in 1992. The triad consists of disordered eating, amenorrhea and osteoporosis and affects physically active girls and women that participate in a wide variety of exercise (American College of Sports Medicine, 1997).

Disordered eating is characterized as any disturbance from a normal eating pattern. While "normal" is typically hard to pinpoint, the American Psychiatric Association has developed criteria for eating disorders. The two well known eating disorders are anorexia nervosa and bulimia nervosa. The third category is "eating disorder not otherwise specified," which is where many are classified because a variety of symptoms are exhibited but cannot be associated with one specific eating disorder. The underlying theme of disordered eating relates to restriction of food intake or bingeing and an overall excessive concern about body shape, body image or weight.

Amenorrhea is the most extreme version of menstrual irregularities and is defined as a complete absence of menstrual periods. While primary amenorrhea, never beginning a menstrual cycle, is possible, secondary amenorrhea is common in exercising girls/women. This is where an individual experiences a lack of menses for three or more consecutive months after menarche. Another category of dysfunction is oligomenorrhea where menstrual cycles are occurring but at intervals longer than 35 days. Finally, the term eumenorrhea is used to characterize normal menses, roughly every 28 days.

The third component of the triad, osteoporosis, is a disease marked by low bone mass and deterioration of bone tissue which leads to frailty and higher bone fracture risk. While osteoporosis is mainly a concern of postmenopausal women, this can also become an issue with younger individuals when participating in excessive exercise/activity that overstresses the bones more than the healthy amount. For this population, osteopenia (lower bone density than normal but not as low as with osteoporosis) is more likely to exist, and can increase the risk for osteoporosis later in life.

The F.A.T. is multi-dimensional, and the newest approach is that scoring positive for only one of the three components indicates that an individual is "at risk." In a study strictly examining 78 elite endurance swimmers, only 1 of 78 (1.3%) met the criteria for all three components, 15.4% (12 of 78) reported positive results for two of the three criteria, and 47.4% (37 of 78) were positive for one of the three components (Schtscherbyna, Soares, Palha de Oliveira, & Ribeiro, 2008). This shows that 50 of the 78 athletes (over 50% of the sample) are at risk for at least one of the F.A.T. components. Clearly, all these athletes should not be overlooked simply because they do not score positive for all three risk factors.

The components of the triad are somewhat exclusive with the way the components are termed. For example, the athletes with oligomenorrhea would not be considered at risk even though their menstrual functioning is not regular. Disordered eating is the only encompassing term because it includes a wide spectrum of health damaging behaviors. The other terms should be exercise related menstrual alterations and osteopenia. The athletes' health is in danger and these factors are highly inter-related so making sure the F.A.T. identifies all females at risk should be a priority (Burrows, Shepherd, Bird, Macleod, & Ward, 2007).

Though "athlete" is part of the F.A.T. term, competitive athletes are not the only population affected. Thompson and Gabriel (2004) compared collegiate and non-collegiate athletes and showed that while the collegiate athlete group had a higher prevalence of a history of stress fractures, the non-collegiate population still expressed this low bone mineral density sign (68% of collegiate athletes compared to 27.9% of non-collegiate athletes). There was a much closer gap in the results when it came to eating disorders as 8.6% of collegiate and 11.1% of non-collegiate athletes responded "yes" to a history of disordered eating. Oligomenorrhea was identified for more collegiate (30.6%) than non-collegiate (16.7%). The findings of Thompson and Gabriel (2004) emphasize that this triad is not solely prevalent in competitive exercisers but the non-competitive exercisers can experience symptoms of the F.A.T. as well. Reinking and Alexander (2005) also found that the nonathlete group had a significantly lower desired body weight compared to the athletes, meaning that body image was likely a problem. This was exhibited in the results where 12.9% of nonathletes compared to 7.1% of athletes were considered at high risk for disordered eating. Overall, the non-competitive athletes and the general exercising population may not be studied as much, but F.A.T. tendencies are still prevalent.

The Physiology of the F.A.T.

Nutrition. Though dietary regimens are typically hard to study due to the inability of ensuring high reliability with self-questionnaires, most research does show that disordered eating is seen amongst all populations. Our consumerism culture highly encourages thin body shapes, and this typically leads to unhealthy eating habits. The question arises whether poor eating behavior is influenced by lack of nutrition knowledge, or if it is based on personal choice despite knowledge such as consciously limiting food intake. While nutrition knowledge was significantly higher for female athletes compared to non-athletes, these individuals did not have a lower score on the Eating Attitude Test which indicates that they are possibly engaging in risk taking behavior to stay lean (Raymond-Barker, Petroczi, & Quested, 2007). Eighty-eight percent of the female endurance runners were also consuming less than the minimum amount of energy recommended when training which is 45 kcal per kilogram of body mass per day. This most likely relates to the sport emphasizing leanness and the athletes being able to justify their poor eating habits despite knowledge of advisable behavior because it is goal oriented for higher performance. While it is a misconception, it seems to be one that misleads a high percent of athletes specifically the lean sport group.

Nutrition unfortunately becomes an overlooked factor by the athletes and coaches because the desire to have the lean, fit body type tends to be more important than having an overall healthy lifestyle. Total energy intake has been found to be the most important factor in healthy diet planning. Bone health is highly dependent upon the vitamins and minerals present in the diet and in the correct proportions. Zinc, calcium and magnesium stimulate bone formation while vitamin D is important to maintain the proper amounts of calcium and phosphorus in the extracellular spaces of bones. While protein is important for rebuilding broken down muscle tissue after an exercise session, it is also highly related to increased bone mineral density. Typically the athletes with higher protein intake also had higher calorie intake and therefore, the chances of having higher bone mineral density increases because the body is not in a deficit (Quintas, Ortega, Lopez-Sobaler, Garrido, & Requejo, 2003).

Rauh, Nichols, & Barrack (2010) studied high school athletes participating in a variety of sports and found that after adjusting the data for body mass index, the injured athletes reported higher mean scores for the EDE-Q disordered eating measure compared to the athletes reporting no injuries. Relative to their energy expenditure, the athletes were deficient on macronutrients and micronutrients which correlates to a higher injury risk. While a food journal was not kept, the athletes who reported elevated dietary constraint were 7.1 times more likely to have an incidence of injury. Therefore, the concern is not always about monitoring food consumption, but educating the athletes on the importance of fueling the body correctly.

Those who have menstrual irregularity have a higher chance of being deficient in some nutrient. For example, 50.72% of collegiate cross country runners reporting amenorrhea or oligomenorrhea had scores below the recommended calcium level, which is 1500 milligrams per day. In comparison, only 22.51% of the female athletes who had normal menstrual status were not consuming the recommended amount of calcium (Thompson, 2007). Calcium has an important function in the maintenance of a strong skeletal system and overall keeping bone density at maximal levels. Calcium and vitamin D also have a role in preventing osteoporosis; therefore, proper nutrition including supplemental vitamins has a significant link to the other parts of the triad, both menstrual irregularity and osteoporosis.

Menstruation and Hormones. Menstrual alterations among athletes are common to the point that they represent a significant health concern. Fifty percent of athletes reported irregularity (defined as nine or fewer menses in the past 12 months or no menarche by the age of 15 years) in a study conducted with female high school athletes (Thein-Nissenbaum, Rauh, Carr, Loud, & McGuine, 2012). This study was completed with participants from a variety of 33 school-sponsored sport teams. The percentages for menstrual irregularity differ depending on type of sport. When dividing the data reported by Thein-Nissenbaum et al. (2012) into subgroups by sport, only 21.4% of the cross country runners reported menstrual irregularity. Swimmers, another endurance sport, reported 23.3% of their sport specific athletes experiencing menstrual irregularity. Sports that had a high percentage of menstrual irregularity in the overall sample (over 10%) were cross-country (12.2%), tennis (12.2%), volleyball (20.4%), and swimming (14.3%). Typically endurance/aerobic athletes will have a higher percentage of menstrual irregularity than non-endurance/nonaerobic athletes. This is likely to do to the fact that aerobic athletes are expending more calories and putting their bodies into an energy deficit, which then causes the functioning of the body systems to decline if recovery is not adequate.

Energy balance is defined as the amount of energy/calories the body expends subtracted from the amount of calories the body takes in. When calories are restricted, the endocrine system is negatively affected and a hormone imbalance is developed that causes menstruation cycles to be disrupted. Loucks, Verdun and Heath (1998) found that low energy availability, rather than exercise stress, is the cause for low serum luteinizing hormone (LH) which ultimately happens because gonadotropin-releasing hormone (GnRH) is suppressed and not secreted by the hypothalamus to trigger LH. When LH is low, estrogen secretion by the ovaries is suppressed. Estrogen is not only a highly important hormone for the menstrual cycle but is important for bone development. Therefore, when the menstrual cycle is disrupted for whatever cause, the risk for stress fractures increases. Athletes with menstrual irregularity compared to athletes with normal menses report a higher percentage of severe musculoskeletal injuries (Loucks, Verdun, & Heath, 1998). Thein-Nissenbaum et al. (2012) reported the underlying cause of the argument is low energy availability which affects the overall cellular maintenance, growth and repair.

Bone density and musculoskeletal injuries. The over-arching argument behind exercise is that, when all else is equal between participants, exercisers should have stronger bones compared to non-exercisers. Every exercise, based upon the type of activity performed, affects the bones in different ways. Weight-bearing exercise is the most beneficial because an estrogenic stimulus is provided to the bones which builds up the bones and keeps the bone mineral density (BMD) at peak bone mass. Bone tissue will continuously respond to a stimulus, and this is not age dependent. Other factors including genetics, age, height, and weight are also factors that influence the amount of loading placed on the bone.

Mode of exercise. Male runners, gymnasts, swimmers, and non-athletes (controls) were compared in regards to BMD and the bone cross sectional (CS) geometry. Data indicated that gymnasts had the greatest BMD followed by the runners, and their data were significantly better than the swimmers because of the nature of the sports. Compared to the control group, the athlete groups overall had greater BMD which supports the theory that exercising is beneficial for bone mineral deposition (Hind, Gannon, Whatley, Cooke, & Truscott, 2011). Gymnastics places the most distribution of loading on the bones compared to running and swimming which produce a regular, repetitive pattern of loading. Running is a weight bearing sport so while overcoming the body's weight, the bones become stronger; however, swimming is non-weight bearing and the loading is not as beneficial because the bones are only having to overcome the force applied by muscles to overcome the water resistance. Another study actually found swimming to negatively influence lower leg BMD (Magkos, Yannakoulia, Kavouras, & Sidossis, 2007).

Exercise frequency. While the connection between menstrual irregularity and musculoskeletal injuries is evident, the link between menstrual irregularity and rate of bone mineral density (BMD) loss is still somewhat uncertain. Pollock et al. (2010) reported that while the females with normal menstrual status would be expected to have normal BMD, this was not the case. With this study, a one-way ANOVA of all the data and then normality plots were completed in order to determine normal BMD. The results supported the theory that increased training volume affected menstrual regularity which then increased the likelihood of lumbar BMD loss.

Exercise Intensity. The intensity of exercise also has a considerably large effect on bone mineral density. Magkos, Yannakoulia, Kavouras, & Sidossis (2007) compared runners and swimmers and in each group, divided the sport also by sprint and endurance athletes. Runners of both types had higher BMD for the legs compared to the swimmers.

However, the sprint runners had the highest leg BMD and the lowest BMD was relatively equal between the sprint and endurance swimmers. This data supported the earlier stated theory that running results in higher ground reaction forces (because the exercise is weight bearing). Two to five times the body weight is applied to the leg for endurance runners while it is four to five times the body weight for sprint runners. The rate at which sprinters are moving and hitting the ground is much faster and the force is much greater than that of the endurance runners. Therefore, the intensity does factor into the type of exercise's effect on bone mineral density.

Similar results were seen in a study Mudd, Fornetti, & Pivarnik (2007) that was done on collegiate females and also correlated the bone mineral density results with menstrual status. Runners and gymnasts reported the greatest menstrual dysfunction, but when relating to BMD values, a positive correlation was not evident. The biggest predictor of BMD values was body mass. The greater the athlete's body mass, the higher the BMD. This makes sense because as the mass increases, the loading with each movement increases with each movement. Low body mass was correlated with menstrual dysfunction, which meant both factors were associated with lower BMD values. Runners having the lowest total body BMD could relate to the intensity and frequency of exercise being excessive to the recommended amount of exercise. Whether there is a threshold to the amount of weight bearing exercise that is beneficial to bone loading has not been determined.

Sports at risk. Runners are studied the most in regards to the F.A.T because this one of the sports that emphasizes leanness. Swimming, gymnastics, dancing, and figure skating are other sports where a lean body shape is highly encouraged by coaches, peers and the overall nature of the sport. Examples of sports not emphasizing leanness include basketball, soccer, volleyball, hockey and softball. Reinking and Alexander (2005) studied collegiate athletes and nonathletes and found that those competing in "lean" sports displayed disordered eating tendencies at a higher rate than the non-lean sports- 2.9% and 25% respectively. This study supported the mentality that is seen consistently across females that you have to "be-thin-to-win." The lean sport athletes scored the highest on The Drive for Thinness scale which is a subsection of the Eating Disorder Inventory.

This high drive for thinness is also associated with markers such as energy deficiency, suppressed reproductive functioning, and greater prevalence of amenorrhea or oligomenorrhea compared to a normal drive for thinness (Gibbs, Williams, Scheid, Toombs, & De Souza, 2011). These internal health risks all begin from a cognitive perspective where the athletes restrain themselves because of a belief that their bodies should look a certain way. Thompson (2007) questioned collegiate cross-country runners, and resulted showed that as the athletes' body mass index (BMI) increased, their personal identification as an athlete decreased. These female athletes felt that their primary goal instead of competing well was now losing weight and achieving the ideal body size. The typical runner is "supposed" to have that thin body type with a low body fat percentage, or at least that is what girls in these lean body sports (such as swimming and running) typically feel pressured to believe.

Irreversible bone loss. Keen and Drinkwater (1997) reported on female athletes as a follow-up study and compared bone mineral density and menstrual status to the initial measurements. Six years later, eight of the oligomenorrheic and amenorrheic (O/A group) had restored a normal menstruation cycle, but the bone mineral density at the lumbar spine was still significantly lower than the athletes who always had regular menstrual cycles. The athletes with normal menstruation have a large advantage, and the athletes who resume regular cycles after a period of amenorrhea or oligomenorrhea have a large curve to catch up to have similar bone mineral densities as the regular menstruation athletes. Normalization of low bone mineral density is highly unlikely with former amenorrheic or oligomenorrheic females indicating that the damage is irreversible.

While some literature argues that bone loss is irreversible, a case report on a woman endurance runner found that with enough changes, bone mineral density and fertility can be recovered (Hind, 2008). This athlete had been diagnosed with an eating disorder while competing at an elite level; however with a recovery from disordered eating along with increases in body mass and body fat percentages, the athlete regained regular menstruation. She also became pregnant despite six years of being amenorrheic, which is a controversial topic whether absence or disruption of menstruation will affect fertility. These results can not be generalized to the entire female athlete triad population because of the innumerable individual health differences.

Treatment

Oral contraceptives. The most common reason to take an oral contraceptive, commonly known as birth control, is to prevent pregnancy; however, there are a number of other reasons to take the pill such as the following: decrease side effects of menstruation, treat acne, and improve estrogen count. Most of the other reasons for taking birth control outside of preventing pregnancy are effective, but will always depend on the individual. Oral contraceptives are shown to have positive effects on bone mass except when consistent medication begins before puberty because estrogen production is suppressed. Age at first oral contraceptive use tends to be the best predictor of vertebral BMD as well as body mass index providing the most consistent correlation for femoral neck BMD (Hartard et al. 2004). Another study reported that amenorrhea was the best predictor for BMD loss, and those athletes started training at an earlier age than their eumenorrhea counterparts and therefore had higher risk for bone loss. This supports the reasoning to encourage athletes with menstrual dysfunction to take an oral contraceptive to increase estrogen in the body (Braam, Knapen, Geusens, Brouns, & Vermeer, 2003). The majority of research on oral contraceptives tends to be conflicted; therefore, it is hard to compare during studies when only a portion of the girls are taking oral contraceptives.

Increase calorie intake. With a decrease in training, it is understandable to notice weight gain or increase in body fat percentage. The body is burning fewer calories due to exercise, and unless the individual reduces the intake of amount of calories appropriately, the individual is likely to gain weight. Energy balance is a function of energy (calories) consumption compared to energy output (basal metabolic rate, thermic effect of food, and exercise). When energy is not balanced, the individual will either gain or lose weight. An energy imbalance is a large component of the female athlete triad that consequently affects menstrual status and bone mineral density. A five year retrospective study compared the menstrual disturbance and restoration of menses with athletes at the University of California, Los Angeles (Arends, Cheung, Barrack & Nattiv, 2012). For those who experienced restoration, all but one of the athletes also experienced weight gain. Females with an increase in body weight of five or more pounds were twice as likely to resume regular menstrual cycles as those athletes who gained only a few pounds. Keen and Drinkwater (1997) also reported that weight gain and restoration of regular menstruation were sufficient adjustments to induce a positive change in bone mineral density. Overall, weight is significantly related to bone mineral density.

Increase knowledge of the F.A.T. The basic factors including the symptoms and consequences of the female athlete triad should become more common knowledge in the exercise world. Parents and coaches should be trained with all the necessary tools to be able to recognize girls whose health is at risk and then be part of the intervention and prevention process. Ideally, this recognition of the female athlete triad symptoms should be a responsibility of a coach. However, when a study asked coaches what the three components of triad were, only four of sixty-one coaches could name all three components. Female coaches were overall able to identify more factors, and they also reported a greater likelihood of discussing the symptoms with their athletes. Overall, when given the option, forty percent of the coaches chose the least proactive option in regards to educating their athletes which meant they would not discuss the triad (Lassiter & Watt, 2007).

A similar question is posed for the athletes/exercising women: Do most active women know about the female athlete triad and its consequences? Miller, Kukulijan, Turner, van der Pligt & Ducher (2012) studied Australian women and reported that even the women who had decent knowledge of several F.A.T. risk factors, a majority believed that amenorrhea is a natural side effect of heavy training. One subject even said, “I’d assume it was because I had lost weight and would therefore be happy!” This comment clearly shows that some women know very little about the negative effects of menstrual irregularity and would not even be alarmed if their menstruation became irregular and would actually desire this health threat.

Athletes typically lean toward one or the other end of the nutrition spectrum. Some athletes have nutrition knowledge and make healthy choices as a result. Others have the knowledge, but still choose either to eat in excess or in shortage. Another possibility is that many athletes, probably the majority, do not have a sufficient knowledge about nutrition to make the choices to fuel their bodies correctly. Nutrition is the cornerstone of an athlete performing at an elite level and reaching their maximum potential. The question is whether it is ignorance or a conscious decision to make unhealthy choices. When comparing between non athletes (control group) and athletes, the components of the F.A.T were more prevalent amongst the athletes. Even the athletes with increased nutrition knowledge did not have higher scores on the EAT-26 which assesses the realm of eating disorders. This means that they may know how to eat properly, but they tend to not follow the advisable behavior. Going a step further, a majority of the female endurance athletes (88%) reported consuming less than the minimum amount of energy required when training which is a mere 45 kcal/kg/day (Raymond-Barker, Petroczi, & Quested, 2007).

Summary

As research has shown, the female athlete triad can affect females of every sport and is primarily a result of a significant calorie reduction in addition to excessive energy expenditure. As the athlete's training volume and intensity increases, the likelihood of this syndrome increases. While coaches typically want their athletes to have optimal or low body fat levels, this typically leads to an unrealistic view of healthy. With low energy intake, hormone levels become low and negatively affect menstrual regularity which then starts a calcium loss process that decreases BMD. To be classified as struggling with the F.A.T., not all three factors have to be identified because they are intricately related to each other. One factor identified should be enough to negatively affect the individual's health.

There are gaps in the research in regards to in depth analysis on endurance exercisers. This group tends to be greatly affected by menstrual dysfunction (because of the large quantity of training altering calorie intake). Both of these sports emphasize leanness which affects the athletes' mentality toward nutrition. The research is not as clear whether more competitive athletes such as NCAA collegiate athletes are more affected by the F.A.T. than the non-competitive athletes. For example, they are under constant scrutiny by coaches, trainers and the media. Because swimming is non-weight bearing, the BMD of these athletes is not as positively affected as other exercisers' BMD. Intensity has been proven to be a factor in regards to menstrual irregularity when comparing sprint and endurance athletes; however, intensity of swimming and running is most likely at a much higher level with competitive athletes than with their non-competitive peers.

Purpose

The purpose of this 2-by-2 cross sectional study was to compare bone density, nutrition knowledge, eating behaviors, and menstrual function in competitive and non-competitive female runners and swimmers. Endurance runners were compared to endurance swimmers to contrast weight bearing and non weight bearing exercise. Runners and swimmers were divided into competitive and non-competitive athletes to compare the effects of training load. This study was multi-dimensional; therefore, it was designed to address the following specific objectives: 1) describe the level of nutritional knowledge and compare to dietary habits; 2) compare the prevalence of disordered eating habits of competitive and non-competitive swimmers and runners; 3) describe the relationship between menstrual function and bone mineral density on musculoskeletal injuries; 4) compare bone mineral density data between the swimmers and runners as well as competitive and non-competitive athletes.

Hypotheses

It is hypothesized that:

1. There will be a greater level of eating disorder prevalence in the competitive group.
2. The runners will exhibit a greater level of eating disorder prevalence, but this will only be true for the competitive athletes.
3. The competitive athletes will score higher on the nutrition knowledge questionnaire.
4. There will be no difference in nutrition knowledge between runners and swimmers in either competitive or non-competitive groups.
5. Competitive athletes will exhibit a greater level of menstrual dysfunction.
6. There will be a greater level of menstrual dysfunction in runners compared to swimmers, but only in the competitive athlete group.
7. Bone mineral density levels will be the lowest to the highest in the following order: competitive runners, non-competitive swimmers, competitive swimmers, and non-competitive runners.

8. Percent body fat levels will be lowest to highest in the following order: competitive runners, competitive swimmers, non-competitive runners, non-competitive swimmers.

An overall hypothesis is that the three components of the female athlete triad will be more prevalent for the competitive athletes.

Significance of the Problem

The foremost significance of this study is to further the scientific knowledge of the female athlete triad. The term female athlete triad has only been labeled as such for twenty years so this has been a trending topic in the exercise world. Practicality wise, the results from this study will be important for physically active females to comprehend how personal health decisions affect the body long term. Prevention is the best method when approaching the female athlete triad, because the effects are damaging to the body and can not be reversible. Knowledge can be gleaned whether competitive/excessive training is more detrimental to an individual's health due to alterations in bone mineral density, menstrual function, and nutritional status.

METHODS

Participants

Female participants between the ages eighteen and twenty-five were recruited from the Texas Christian University undergraduate population. There were nine swimmers and twenty runners total. Four swimmers were non-competitive exercisers, five runners were non-competitive exercisers, five swimmers were competitive athletes, and six runners were competitive athletes. Participants were considered to be competitive athletes if participating in NCAA Division I cross country/track or swimming teams at the university. The long distance athletes were the targeted population. For track and field, this meant the athlete trained to race the mile or distances above the mile. For swimmers, long distance athletes included those who train for the 500, 1000, or 1650 yard races. The competitive athlete had to be training consistently with their respective team under coach supervision, and workouts had to be completed alongside teammates. The group of non-competitive athletes included females who train in that specific type of exercise (swimming or running) five times a week at most. All participants signed a university-approved consent form prior to participation.

Experimental Design

This experiment was a two by two cross sectional design. There were four groups (competitive swimmers-CS, competitive runners-CR, non-competitive swimmers-NS, and non-competitive runners-NR) based on the two independent factors: level of competition (competitive and non-competitive) and exercise mode (running and swimming). The measures were completed in late March and early April which was the off season for the competitive swimmers while the competitive runners were in season for track.

Experimental Testing

There were multiple dependent assessments made in order to address the three different factors of the female athlete triad (disordered eating, osteoporosis, and menstrual dysfunction). The primary instruments used in this study include the EDE-Q 6.0, a researcher designed questionnaire, and Dual Energy X-Ray Absorptiometry (DEXA) densitometer. The questionnaire designed by the researcher included questions about nutrition and osteoporosis knowledge, menstrual history, and injury history.

Demographic. Information was gathered from the demographic questionnaire which included date of birth, height, weight, and race. Anthropometric measurements were taken by a trained researcher using a digital scale (Nichols Scale) accurate to the nearest 0.2 kilogram and a stadiometer accurate to the nearest 0.5 centimeter.

Disordered eating. The Eating Disorder Examination Questionnaire (EDE-Q 6.0), shown in Appendix B, was used to examine the degree of disordered eating for each participant. This measure is composed of twenty-eight questions that assess multiple subscores including restraint, eating concern, weight concern, and shape concern. Participants were asked to answer the EDE-Q 6.0 based upon the past twenty-eight days. The scoring system is based on a seven point continuum scale with 0 indicating a version of "no days *or* not at all" and 6 indicating “every day *or* markedly.” Each subscale has certain questions and the scores are added together and then divided by the number of subscales items to obtain a subscale average. All of the subscales are then added together and divided by four to obtain a global EDE-Q score. A study using 723 undergraduate women from the United States was used to establish the EDE-Q norms. This produced a global score of 1.74 with a standard deviation of 1.30 (Luce, Crowther, & Pole, 2008).

Dietary restraint is a behavior described as limiting calorie intake in hopes of achieving weight loss so this subscale (questions 1, 2, 3, 4, and 5) measures dietary rules and food avoidance. For example, two questions ask, “have you been deliberately trying to limit the amount of food you eat to influence your shape or weight?” and “have you tried to exclude from your diet any foods that you like in order to influence your shape or weight?” The restraint comparative mean is 1.62 with a standard deviation of 1.54 (Luce, Crowther, & Pole, 2008).

Eating concern measures guilt about eating, fear of losing control over eating, eating preoccupation and secretive eating. This subscale has five items which are questions 7,9,19, 20, and 21. An example of an eating concern question is “has thinking about food, eating, or calories made it very difficult to concentrate on things you are interested in (for example, working, following conversation, or reading)?” The comparison norm for eating concern is a mean of 1.11 with a standard deviation of 1.11 (Luce, Crowther, & Pole, 2008).

Weight concern is a characteristic of individuals who are overly concerned with their body weight. This subscale includes questions 8, 12, 22, 24 and 25, and an example question is “have you had a strong desire to lose weight?” The comparison data for weight concern is 1.97 with a standard deviation of 1.56 (Luce, Crowther, & Pole, 2008).

The shape concern category (questions 6, 8, 10, 11, 23, 26, 27 and 28) measures the individual’s fear of fatness, discomfort with self and others seeing the body, as well as a preoccupation with her body shape. One question asks, “Have you felt fat?” and another asks, “Has your shape influenced how you think about (judge) yourself as a person?" The comparison norm for shape concern is 2.27 with a standard deviation of 1.54 (Luce, Crowther, & Pole, 2008).

Nutrition and Osteoporosis knowledge, menstrual and injury history. This questionnaire, shown in Appendix A, was designed by the researcher based on literature reviews, and the primary goal was to gain basic knowledge on the health of the participant as well as her knowledge of various subjects. The first five questions ask general nutrition knowledge questions, and the next five questions ask about osteoporosis/calcium knowledge.

The next questions about physical activity were asked in attempt to classify the athlete according to the amount, type, and intensity of exercise performed on a weekly basis. Other questions pertained to bone and/or muscle related injuries experienced as well as severity of those injuries. The athletes were also questioned about their attachment to the exercise.

The menstrual history questions were designed to determine the athlete's menstrual status, and whether she is regular or irregular. Athletes were identified oligomenorrheic if they have had nine or less cycles in the past year. If they have had zero cycles or have never started menstruation, then they were considered amenorrheic. Both of these classifications indicated that the athlete is at risk for the female athlete triad.

Bone density and body composition. The iDXA dual x-ray absorpiometry densitometer (DXA) made by General Electric (GE) was used to measure bone density and to determine whether the female is at risk for osteoporosis. In this study, total body bone mineral density measurements were calculated. Spine, pelvis, legs and overall total body bone mineral densities were used as comparisons. DXA also yields measurements for body composition which were used to compare athletes.

Procedure. Competitive athletes were recruited through the TCU Swimming coach and the TCU Track and Field coach. The non-competitive athletes were recruited through word of mouth. Following voluntary sign-up and consent, the researcher scheduled times to meet with each individual. The participants came to the TCU Kinesiology Lab for two visits. The first visit was to complete the two questionnaires, and the second time was to get anthropometric, body composition and bone mineral density measurements. The subjects were encouraged to answer the questionnaires completely and honestly. When arriving at the lab the second time, the participants were told to wear exercise clothes or other clothes that did not have contain metal like a zipper or button. All jewelry must also be removed. Shoes were removed while the participant's height and weight measurements were taken. Then the participant was told to lay on her back on the DXA table. The participant's body was to be lined up centrally with the markings on the table. Then the researcher strapped the participant's knees together as well as her ankles. Then the researcher started the DXA test which took approximately seven minutes for the scanner to pass over the entire body. The participant was told to lie still for the duration of the scan. After all measurements were taken with the DXA, the participant had completed the study.

Statistical Analysis

A two-factor, between groups-analysis of variance (ANOVA) was used to determine differences between exercise mode (swimming and running) and between level of competition (competitive and non-competitive). This test was performed on all dependent measures. In addition, simple correlations were conducted between all dependent measures to determine possible relationships. An alpha level of $p < 0.05$ was used to establish significance for all procedures and a $p < 0.1$ indicated a trend.

RESULTS

Disordered Eating

There was one non-competitive runner who did not complete the entire EDE-Q 6.0; therefore, her data were not included in the analysis because scores for subcategories could not be found. The scores for the EDE-Q 6.0 across groups are reported in Table 1. There was no significance found between level of competition or mode. Scores between 4 and 6 indicate eating disorder tendencies, and no group average or individual's score was near that range. While there was little difference in averages, the competitive swimmers scored the lowest for the global EDE-Q 6.0 score, and the competitive runners scored the highest. There were 3 participants total that scored close to the eating disorder tendency range for the "restraint" category. These three participants were not primarily from one group indicating no trend there.

	Global	**Restraint**	**Eating Concern**	**Weight Concern**	**Shape Concern**
NR	1.474	1.64	0.92	1.65	1.775
NS	1.436	1.9	0.55	1.2	2.094
CR	1.594	1.6	1.4	1	2.375
CS	1.283	1.12	0.8	1.36	1.85

Table 1. EDE-Q 6.0 Global and subscore values for each group. Scores between 4 and 6 indicate eating disorder tendencies.

Nutrition and Osteoporosis Knowledge

For the osteoporosis and nutrition knowledge questionnaires, no significance was found for either factor when comparing by mode or level of competition. There was a trend ($p = 0.098$ for both factors) indicating that runners and competitive athletes had a higher score on the nutrition knowledge questionnaire. Competitive runners scored the highest (4.67 out of 6) for the nutrition knowledge, and the non-competitive swimmers scored lower (2.75 out of 6). There was no trend found for the osteoporosis knowledge questions. All group averages ranged from 2.75 to 3.83 with the non-competitive runners scoring the highest and the non-competitive swimmers scored the lowest. Table 2 shows scores for both nutrition and osteoporosis knowledge categories by group, and Figure 1 shows the scores in a graph.

	Nutrition Knowledge	**Osteoporosis Knowledge**
NR	4	3.83
NS	2.75	2.75
CR	4.67	2.83
CS	4	3

Table 2. Nutrition and Osteoporosis Knowledge (scores out of 6). Values represent the mean for the group.

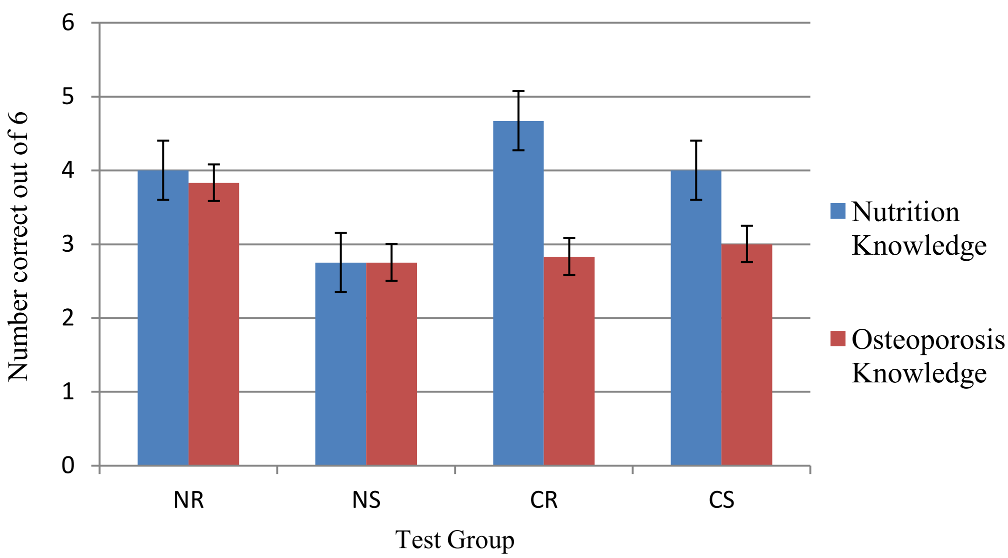


Figure 1. Nutrition and Osteoporosis Knowledge. Values are averages for the group with possible score from 0 to 6.

Menstrual Function

Competitive athletes reported more menstrual dysfunction (7.0 $\pm$ 5.099 vs. 11.2 $\pm$ 1.1687 cycles/yr) than non-competitive athletes (p=0.026). The competitive runners had the most menstrual dysfunction with two subjects being amenorrheic and two being oligomenorrheic making this group's menstrual function average 5.67 cycles per year. Three of six competitive swimmers were oligomenorrheic and two of six non-competitive runners were oligomenorrheic. All of the non-competitive swimmers were eumenorrheic. Figure 2 shows average number of menstrual cycles per year for each of the groups.

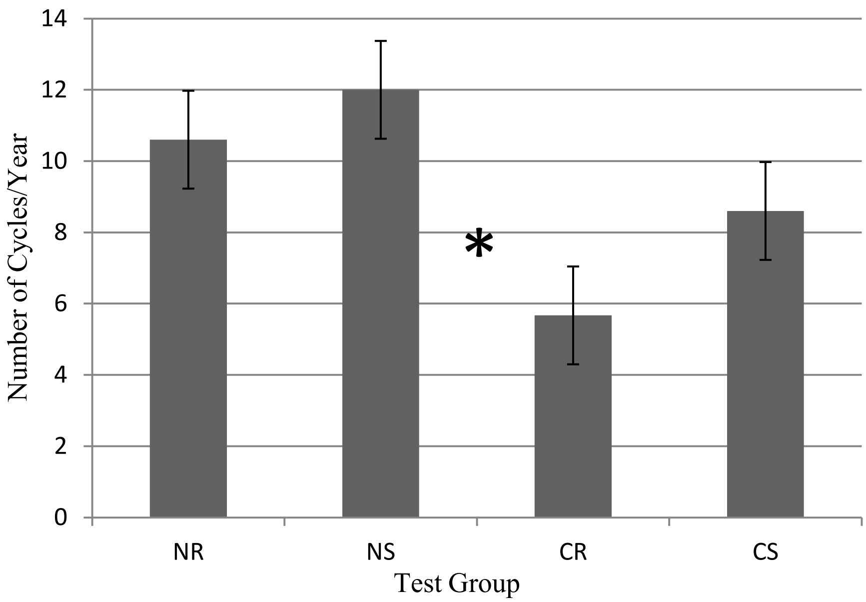


Figure 2. Number of menstrual cycles per year by group.
*Indicates competitive different from non-competitive (p=0.026)

Bone Mineral Density

The exercise mode had a significant main effect (p= 0.044) on leg BMD. Runners had higher leg bone mineral density than swimmers (1.109 $\pm$ 0.125 vs. 1.158$\pm$ 0.108 g/cm^2). There was a trend (p=0.068) that non-competitive athletes had higher total body BMD than competitive athletes (1.18 $\pm$ 0.09 vs. 1.08$\pm$ 0.125 g/cm^2). Bone mineral density levels by group are given in Figure 3 for total body, leg, pelvis, and spine BMD. Non-competitive runners had highest bone mineral density for each area, and competitive swimmers had the lowest for all areas besides the spine BMD where competitive runners scored lowest. Table 3 shows BMD measurements by group for total body, leg, pelvis, and spine. Figure 3 shows BMD by group for total body and leg, and Figure 4 shows bone mineral density by group for pelvis and spine.

	Total Body BMD (g/cm^2)	**Leg BMD (g/cm^2)**	**Pelvis BMD (g/cm^2)**	**Spine BMD (g/cm^2)**
NR	1.203	1.265	1.176	1.115
NS	1.146	1.2	1.097	1.079
CR	1.114	1.223	1.069	0.99
CS	1.045	1.084	0.992	1.012

Table 3. Bone mineral density (BMD) measurements. Values above 1.1 g/cm^2 indicate healthy bones for this age group.

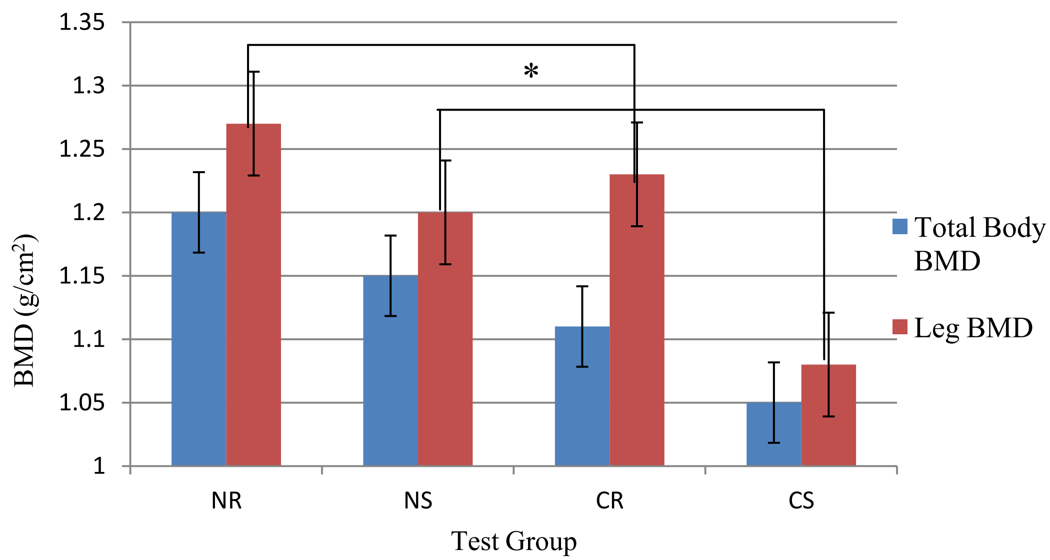


Figure 3. Bone mineral density (BMD) measurements for the total body and leg. *Significance at p=0.044 for leg BMD was found when comapring by mode. Swimmers had lower bone mineral density when compared to runners.

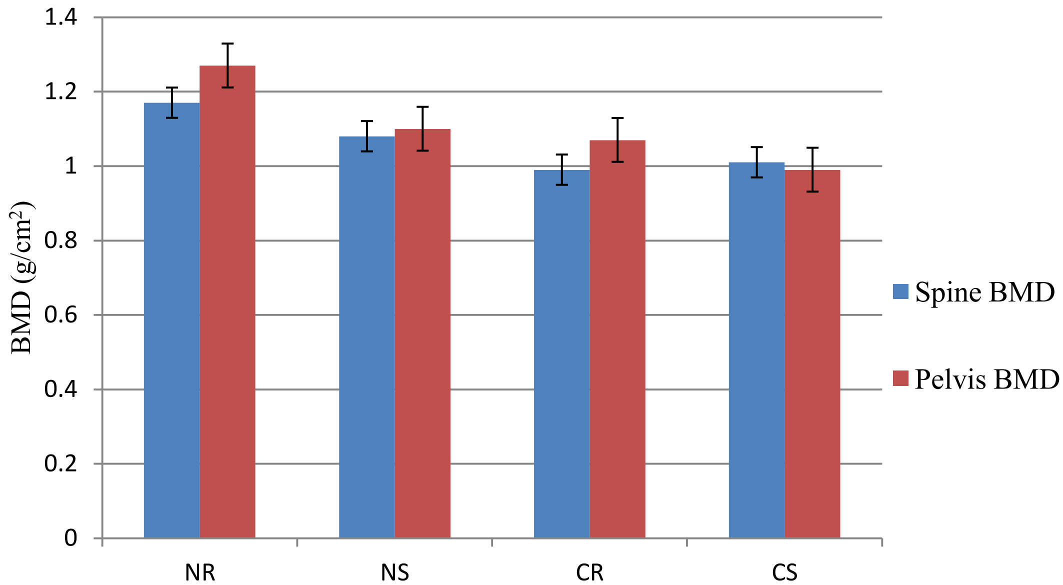
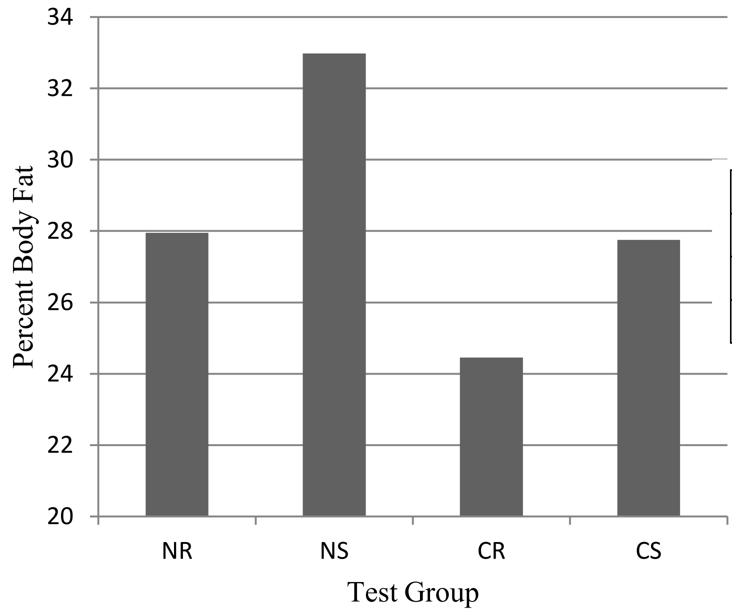


Figure 4. Bone mineral density (BMD) levels for the spine and pelvis. Values represent the mean for each group.

Body Composition

No significance was found for percent body fat in the participants; however a trend was found that both runners (p=0.096) and competitive athletes (p=0.082) had lower percent body fat. Competitive runners had the lowest total percent body fat at 24.45. Figure 5 shows percent body fat by group.



NR	27.95
NS	32.98
CR	24.45
CS	27.75

Figure 5. Percent body fat levels. Values represent the mean by group when compiling body fat percentages obtained from the DEXA scan.

DISCUSSION

Disordered Eating

Hypotheses 1 and 2 were not supported since global scores on the EDE-Q were low (scores between 4 and 6 indicate eating disorder tendencies). The fact that both running and swimming are “lean body” sports may explain why one group was not more at risk than another; however, because they are sports where a lean physique is emphasized, higher scores of eating disorder tendencies were expected. Perhaps if athletes from a non-lean sport such as soccer or softball were compared against runners or swimmers, significance may have been found between lean sports and non-lean sports. That would have been consistent with a study by Reinking and Alexander who found “lean” sport athletes were at greater risk for disordered eating. Instead, the results of the current study are similar to a study by Hopkinson and Locke (2004) who found that type of sport (swimmers, runners, and soccer players) showed no significant effects for disordered eating.

Our results showing no significance by level of competition are not consistent with the study by Thompson and Gabriel (2004) who found non-competitive athletes to exhibit more eating disorder tendencies than the competitive athletes. In our study, 14% (3 of 20) of participants had scores on the “restraint” factor that approached a value of 4 indicative of an eating disorder. The restraint category is related to anorexia nervosa tendencies; however, no trend by group can be made because these three participants were from each group besides competitive swimmers. There was not a group that had more than one participant close to restraint eating disorder tendencies so the three cases seem to be random and unrelated.

Nutrition and Osteoporosis Knowledge

The trends in the nutrition knowledge data partially supported hypotheses 3 & 4 since CR & CS scored higher than NR & NS; however, there was a difference by mode where runners tended to score higher than swimmers. This is consistent with results by Raymond-Barker, Petroczi, and Quested (2007) where female athletes scored higher on nutrition knowledge when compared to female non-athletes. This study also found that even though athletes may have been more knowledgeable about nutrition, they reported to not eat enough calories for the amount of calories expended. This shows that while they may have the knowledge, there is the possibility that the knowledge will not be utilized when choosing a healthy diet.

Turner and Bass (2001) reported that female athletes scored 70% on an osteoporosis knowledge questionnaire, indicating moderate knowledge of osteoporosis in general, and facts about prevention. When asked about calcium, 92% of participants knew its role in decreasing risk for osteoporosis when obtained in adequate amounts in the diet. Another important factor in osteoporosis prevention is regularly participating in weight-bearing exercise, and this can be achieved by activities such as running and walking that put stress on bones and ultimately increase bone mineral density. Our study found that only 19% (4 out of 21) of participants understood that between walking, swimming, bicycling and yoga, walking has the best effect on bone growth. Forty-eight percent of participants (10 out of 21) answered swimming. It is important to be able to differentiate between weight bearing and non-weight bearing exercise; therefore, more educational interventions are needed for this to become more common knowledge.

Menstrual Function

Hypotheses about menstrual function were supported based on the significantly higher incidence of menstrual irregularity in CR & CS compared to NR and NS, and the tendency in CR for fewer menstrual cycles versus CS. This variable showed the most significance indicating that the increased exercise frequency and intensity associated with competitive athletes largely affects menstrual functioning. Two competitive runners were amenorrheic, and this irregularity was found only in this group. There were oligomenorrheic athletes in all of the groups except for non-competitive swimmers. Menstrual dysfunction can be common in non-competitive athletes; however, this study showed that competitive athletes are more at risk for this component of the female athlete triad. This is consistent with the results from Thompson and Gabriel (2004) who found that more athletes report oligomenorrhea compared to individuals who were not currently competing in a sport.

Both sports studied (swimming and running) are endurance sports, and typically more menstrual irregularity is seen with this type of sport (Thein-Nissenbaum, Rauh, Carr, Loud, & McGuine, 2012). In our study, 38% (8 of 21) of participants reported menstrual irregularity (reporting less than 10 to 12 menstrual cycles per year). This percentage is less than the study by Thein-Nissenbaum et al. (2012) where fifty percent of athletes had menstrual dysfunction. Our results are consistent with those from Mudd, Fornetti, & Pivarnik (2007) that runners reported one of the highest degrees of menstrual dysfunction compared to the other sports. Typically, menstrual dysfunction is due to an energy imbalance, and this indicates that runners are more likely to not consume an adequate amount of calories for the amount expended during exercise. When energy output does not equal energy input, gonadotropin-releasing hormone (GnRH) is suppressed which then causes luteinizing hormone to be low which ultimately disrupts estrogen secretion (Loucks, Verdun & Heath, 1998). Then the individual's endocrine system is not in homeostasis which then negatively impacts the rest of the body such as the reproductive and musculoskeletal systems. Menstrual function is not always related to eating habits; however, these components are highly interrelated.

Bone Mineral Density

The order of total body BMD from low to high was: CS, CR, NS, and NR; thus, the precise order hypothesized was not supported; The NR group did, however, have the highest BMD, the position of that group does match our hypothesis. This is evidence that both mode of exercise as well as exercise intensity and frequency have an effect on bone mineral density. Swimmers overall had lower leg BMD than runners, and this was expected due to the non-weight bearing aspect of the sport of swimming. This finding is consistent with results reported by Hind, Gannon, Whatley, Cooke, and Truscott (2011) where swimmers had lower BMD than gymnasts and runners. With swimming, there is no impact stress on the bones during exercise, unlike running or other weight bearing exercise where every step taken provides additional load that can positively affect bone growth. The competitive swimmers in our study had an average that was below the 1.1 g/cm^2 population average for this age group. This is of concern because even though these competitive athletes are fit, their bones are not being stressed adequately, causing them to be at higher risk for bone injury and also for osteoporosis later in life. While competitive runners had higher leg BMD, their average for spine BMD was below the 1 g/cm^2. Having a high BMD in the legs is important for their sport type, but when these individuals get older, it is important to also have high spine and pelvis BMD to avoid the development of a kyphotic spine curvature or also a pelvis fracture, which is extremely common with age. The increased frequency and intensity associated with competitive running may be negatively affecting the spine because the non-competitive runners had the highest spine BMD.

The fact that CR did not have higher BMD largely shows that the increase in amount of weight bearing exercise is no longer having a positive effect on the bones. This indicates that there is a threshold of the amount of stress the bones can handle before the bones start to weaken due to overuse. The risk for stress fractures and other bone related injuries is then increased due to weaker bones. The idea of increased intensity and stress on the bones was thought to be similar to comparing sprint runners and endurance runners, but this does not seem to be the case. Sprinters have been found to have higher BMD (Magkos, Yannakoulia, Kavouras & Sidossis, 2007), but in our study, competitive athletes had lower BMD than the less intense non-competitive athletes.

The relationship between low BMD and menstrual dysfunction was also apparent in our study because the competitive athletes had lower total body BMD as well as overall more menstrual dysfunction. Menstrual dysfunction may be affecting BMD because estrogen is being secreted less or not at all depending on whether the athlete is oligomenorrhic or amenorrheic. Estrogen is an important hormone in regulating bone resorption so without estrogen, bones are more likely to break down resulting in stress fractures or other bone related injuries (Braam, Knapen, Geusens, Brouns, & Vermeer, 2003). Birth control typically has estrogen which can be helpful when the individual is not ingesting enough calories to keep at a healthy hormone balance. However, it is important to remember that birth control introduces uncertainty as to the hormonal status of the subjects participating in the study. Some females may seem as though their hormones are in balance due to birth control and other individuals may be taking birth control for other reasons but are still getting the additive estrogen benefit. In the current study, birth control is seen as a limiting factor because participants were not excluded from participation if they were currently taking birth control.

Body Composition

The trend in body composition supported hypothesis 8 since CR & CS had lower percent fat than NR & NS. This shows that the higher exercise intensity and frequency will be beneficial when trying to maintain a lean physique. This is likely due to increased calorie expenditure but this also shows that these competitive athletes have understood to at least some extent how to fuel their body and find a balance between energy input and output. Also, the competitive nature of exercise has helped the athletes build more lean body mass compared to the non-competitive athletes.

In past research by Mudd, Fornetti, & Pivarnik (2007), higher body mass was a strong predictor of higher BMD. This is consistent with our data because the non-competitive athletes had higher body masses, and they also had higher BMD. Because NS had the highest body mass and did not have the strongest bones, this was not a perfect relationship; however, this is important to notice that body mass and bone mineral density are interrelated. With each weight bearing movement, more loading is put on the bones when there is increased body mass; however, this does not imply that it is beneficial to be overweight simply to put more stress on the bones. There is a healthy balance between body mass and bone mineral density, and this was best achieved by the NR who had the highest BMD while maintaining a normal body mass index. Overall, weight-bearing exercise (running) can be more beneficial than swimming for maintaining a high bone density; however, the greater training load of both the CR and CS may interfere with optimal bone metabolism, despite the fact that it is helpful in maintaining a healthier body composition.

Implications

The F.A.T. is not something to be taken lightly. Many more comprehensive studies are needed to obtain more of the missing links between the three interrelated components. For example, it is unknown whether the F.A.T. always starts with energy insufficiency even though this would make sense physiologically because energy deficits lead to reduced estrogen levels, which then negatively affect bone growth. While there were no individuals who were considered at risk with eating disorder tendencies, a small percentage of participants were at risk for menstrual dysfunction and/or low bone mineral density. With the criterion of scoring positive for at least one of the F.A.T. components, 3 CR and 3 CS would be at risk. If the menstrual dysfunction component was expanded to include oligomenorrhea (9 or less periods), 2 NR and 1 more CR would also be at risk. While these individuals may be unaware, their health is in danger. Amenorrhea or oligomenorrhea may be considered the "norm" for athletes, but it is not considered normal (Miller, Kukulijan, Turner, van der Pligt & Ducher, 2012). These individuals should be looking for ways to decrease their exercise intensity and frequency, and if that is not possible due to being under the supervision of a coach, then the athletes should attempt to increase the amount of calories ingested. If these components of the F.A.T.

persist over a long period of time, there is an increased risk for irreversible bone loss (Keen and Drinkwater, 1997).

Competitive athletes were at higher risk for the F.A.T. compared to non-competitive exercisers, and these were the athletes who were participating in NCAA Division 1 swimming or track and field. It is important for athletes and coaches to be aware of the effects of the female athlete triad. Knowledge is power, and an easy component to identify that the athlete is at risk would be menstrual dysfunction. This is an easy question for coaches or trainers to ask their female participants, and much insight can be gleaned about the athletes' health that cannot always be seen from the outside. For example, it is not difficult for individuals to keep their unhealthy eating habits a secret. Being proactive and educating the public is the best approach for the F.A.T. considering the components are all physiological and not always noticeable until the extremes of an eating disorder become apparent. NCAA athletes have many more pressures compared to individuals who are solely exercising for health reasons; however, this does not mean the non-competitive exercisers should be overlooked.

More recently, the three components of the F.A.T. were each put on a continuum. Instead of amenorrhea being the identifying criteria, females with any degree of menstrual disturbances are now considered at risk. This is the same with eating disorders where individuals with low energy availability are at risk. If individuals who are considered subclinical are overlooked and then never reexamined after a period of time, this is dangerous because these components can change rather quickly. Considering six of the twenty one participants of the study were oligomenorrheic, all of these individuals would have been ignored. It is critical for all individuals who are at risk for the triad to be identified, and making the components on a continuum is headed in the right direction for that to happen.

Limitations

There are a few limitations to this study that may have affected the validity of the results. The sample was random; however, the qualifications to participate were not very exclusive. To truly compare nutrition knowledge between the groups, it should have been a criterion to not have taken any nutrition classes. This could have affected the results because 50% of the non-competitive runners had taken one or more nutrition classes previously. In the other groups, only one CR and one CS had taken a class about proper nutrition. Another factor to take into consideration was that 6 participants were currently taking birth control. Most birth control contraceptives contain estrogen which is the important hormone in preventing bone resorption. Therefore, it is not appropriate to have a mixed population of females with only some taking birth control. These should have been factors that were controlled when recruiting participants, but that most likely would have made my sample size even smaller.

Our study had a total of 21 participants, and this small sample size reduces the statistical power necessary to find significance; thus there is a chance that differences existed between groups were missed. Significance was found with two variables, but if the sample size was larger, the trends are likely to become significant. Also, the participants of this study were somewhat homogenous. All participants were current Texas Christian University students, the average age was 19.52 years and the population was 81 percent Caucasian. Therefore, these results are not generalizable to a greater population outside of TCU, and the external validity of the study is relatively low.

Recruiting participants was somewhat difficult due to time restraints and the participants that were available. The non-competitive swimmers were the group most difficult to recruit, and whether that was due to a low population of recreational swimmers in this age group at this university is unknown. Some of the participants may not have been exclusively swimmers as well. For example, one participant who was classified as a non-competitive swimmer competes in recreational triathlons. She reported to swim more frequently than running, but her BMD may not be the most accurate to be classified as a non-competitive swimmer. Also, the age range used for this study may have been too inclusive because the affects of four years of competition on the body are much different from one year. Perhaps the age group should have only been upperclassmen or lowerclassmen.

Lastly, questionnaires are the not always the most reliable form of obtaining data. While the EDE-Q 6.0 has been shown to be valid and reliable in previous studies (Luce, Crowther, & Pole, 2008), the fact that we used a questionnaire could be a possibility why no significant data was found with our sample. While participants were asked to answer all questions honestly, it is unknown whether the participants took the study seriously. The questionnaires used in this study addressed personal information (eating habits and menstrual function), and if the participants had issues with any of the topics, they might not have responded as truthfully in the questionnaire. The only alternative would be to ask the individuals some of these questions in an interview.

In the future, another eating disorder questionnaire might be utilized instead of the EDE-Q 6.0. While this questionnaire is valid and reliable, there are many questionnaires that address eating disorder tendencies, and there has not been one questionnaire that has been designed specifically for this age group. For example, there is the Eating Disorder Inventory utilized by Reinking and Alexander (2005) or the Structured Inventory for Anorexic and Bulimic eating disorders (SIAB-S) which was used in Burrows et al. (2007). Also, there is an interview format of the EDE-Q which might yield more valid results because then the researcher may pick up on tendencies that the participant might not feel comfortable answering in a questionnaire format. However, to perform the interview format, the researcher must be adequately trained.

Future Study

More research is needed on the F.A.T. and the current study could easily be expanded. Participants should be recruited from other areas and possibly other universities. It is important for the research field to understand the prevalence of the F.A.T. across multiple age groups, but this is an important age group to study due to the large number of collegiate athletes across the country who may be at risk. The F.A.T. has been studied on a regular basis for the past decade or more, and is time to see if the syndrome has increased, decreased or maintained its prevalence. This pilot study effectively investigated each component of the F.A.T., and this comprehensive approach should be performed with each study so that complete information is available.

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APPENDIX A

QUESTIONNAIRE
NUTRITIONAL KNOWLEDGE AND HABITS, ACTIVITY, MENSTRUAL FUNCTION, AND INJURY HISTORY

1. How many excess calories in your diet will cause you to gain a pound of fat?
    a. 1500
    b. 2500
    c. 3500
    d. 4500
2. Vitamins and minerals are a good source of energy for the body.
    a. True
    b. False
3. The words "glucose," "sucrose," and "fructose" on a product label indicate what type of ingredient?
    a. Fiber
    b. Protein
    c. Sodium
    d. Sugar
4. Which of the following is not a fat soluble vitamin?
    a. Vitamin A
    b. Vitamin C
    c. Vitamin D
    d. Vitamin K
5. Which of the following macronutrients is the most energy dense (most calories per gram):
    a. Carbohydrate
    b. Fat
    c. Protein
    d. Minerals

6. Which of the following statements is NOT true about water?
    a. Fruits and vegetables contain water
    b. Water makes up over 2/3 of the human body weight
    c. The body can function well without water
    d. Dehydration can result from low intake of water
7. What is the primary benefit of consuming Vitamin D?
    a. Aids in absorption of calcium
    b. Assists in blood clotting
    c. Help the immune system fight infection
    d. Benefits skin health
8. Which of the following is NOT a risk factor for osteoporosis:
    a. Smoking
    b. Having a thin, small frame
    c. Personal and/or family history of bone fractures
    d. Regularly participating in weight-bearing exercise
9. What mineral is most important for bone growth?
    a. Iron
    b. Zinc
    c. Calcium
    d. Phosphorus
10. Which food contains the most calcium per serving?
    a. Low-fat milk
    b. Spinach
    c. Low-fat yogurt
    d. Cream cheese
11. Which type of exercise has the best effect on bone growth?
    a. Swimming
    b. Walking
    c. Bicycling
    d. Yoga

12. Which of the following statements is NOT true in regard to osteoporosis?
    a. This diagnosis is a natural part of aging
    b. It is characterized by weak and brittle bones
    c. It is the most prevalent bone disease
    d. There is an increased risk for women
13. How would you rate your overall knowledge of proper nutrition?
    Very knowledgeable
    Somewhat knowledgeable
    A little knowledgeable
    Not at all knowledgeable
14. How would you rate your overall use of nutrition knowledge in your current dietary habits?
    Very well
    Somewhat well
    Not so well
    Not well at all
15. Would you say you are at your ideal weight? YES NO
    a. If you answered no, how many pounds would you desire to lose?
    ____
16. Has anyone ever suggested you lose weight or change your eating habits?
    YES NO
17. At any point, have you had a consultation with a nutritionist? YES NO
18. Do you take a calcium supplement? YES NO
19. Do you take an iron supplement? YES NO
20. Do you take a multivitamin? YES NO
21. On average, how many sessions a week do you engage in physical activity?
    ____
22. On average, how many minutes does a physical activity session last?
    ____
23. Would you say the intensity of the workout is light, moderate or vigorous?
    ____

24. Do you worry if you have missed a workout? YES NO
25. Do you exercise/are you physically active as well as training for your sport?
YES NO
26. Do you currently have a bone or muscle injury due to training? YES NO
Bone or muscle injury examples include: stress fracture, pulled or strained muscle, broken bone, etc.
    a. If yes, what type(s) of injury (muscle or bone)?_________________________
27. Have you had a bone or muscle injury due to training in the past?YES NO
    a. If yes, what type(s) of injury (muscle or bone)?_______________________________
    b. How long did this injury prevent you from training?
    ____
28. Are you hesitant to stop working out when an injury arises? YES NO
Why or why not?____
29. Circle the following that best describes your current menstrual status:
    - Have not started menstruation
    - Number of cycles in past 12 months:

0	1-3	4-6	7-9	10-12	>12

30. Are you currently taking a form of birth control? YES NO
    a. If yes, how long have you been taking this medication?
    ____
    b. What was the primary reason to start taking the medication?
    ____
31. If you are not currently, have you ever taken birth control? YES NO
    a. How long were you on the medication?
    ____
    b. What was the primary reason for taking the medication?
    ____
    c. Why did you stop taking the medication?
    ____

32. Do you notice changes in your menstrual cycle throughout the course of your training (e.g. less periods during the intense periods of training)? YES NO
    a. If yes, what do you notice:

    ____

33. Does your menstrual cycle affect your training? (e.g. cannot practice) YES NO
    a. If yes, how is your cycle affected?

    ____

34. What is your age? _________
35. What is your race?
    a. African American
    b. Asian
    c. Caucasian
    d. Hispanic or Latino
    e. Native American
    f. Pacific Islander
    g. Other
36. What is your school classification?

    Freshman Sophomore Junior Senior
37. What is your major? ___________________________
38. Have you taken a nutrition class? YES NO
    a. If yes, please list the number and title of the classes:

    ____

APPENDIX B

Form B.2. Eating Disorders Examination Questionnaire (EDE-Q)
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Instructions: The following questions are concerned with the past 4 weeks (28 days) only. Please read each question carefully. Please answer all the questions. Thank you.

Questions 1-12: Please circle the appropriate number on the right. Remember that the questions refer to the past 4 weeks (28 days) only.

On how many of the past 28 days…	**No days**	**1-5 days**	**6-12 days**	**13-15 days**	**16-22 days**	**23-27 days**	**Every day**
1. Have you been deliberately trying to limit the amount of food you eat to influence your shape or weight (whether or not you have succeeded)?	0	1	2	3	4	5	6
2. Have you gone for long periods of time (8 waking hours or more) without eating anything at all in order to influence your shape or weight?	0	1	2	3	4	5	6
3. Have you tried to exclude from your diet any foods that you like in order to influence your shape or weight (whether or not you have succeeded)?	0	1	2	3	4	5	6
4. Have you tried to follow definite rules regarding your eating (for example, a calorie limit) in order to influence your shape or weight (whether or not you have succeeded)?	0	1	2	3	4	5	6
5. Have you had a definite desire to have an empty stomach with the aim of influencing your shape or weight?	0	1	2	3	4	5	6
6. Have you had a definite desire to have a totally flat stomach?	0	1	2	3	4	5	6
7. Has thinking about food, eating or calories made it very difficult to concentrate on things you are interested in (For example, working, following a conversation, or reading?)	0	1	2	3	4	5	6
8. Has thinking about shape or weight made it very difficult to concentrate on things you are interested in (For example, working, following a conversation, or reading?)	0	1	2	3	4	5	6

On how many of the past 28 days…	No days	1-5 days	6-12 days	13-15 days	16-22 days	23-27 days	Every day
9. Have you had a definite fear of losing control over eating?	0	1	2	3	4	5	6
10. Have you had a definite fear that you might gain weight?	0	1	2	3	4	5	6
11. Have you felt fat?	0	1	2	3	4	5	6
12. Have you had a strong desire to lose weight?	0	1	2	3	4	5	6

Questions 13-18: Please fill in the appropriate number in the boxes on the right. Remember that the questions refer to the past 4 weeks (28 days) only.

Over the past 4 weeks (28 days)…	
13. Over the past 28 days, how many times have you eaten what other people would regard as an *unusually* large amount of food (give the circumstances)?	________
14. On how many of these days did you have a sense of having lost control over your eating (at the time that you were eating)?	________
15. Over the past 28 days, on how many days have such episodes of overeating occurred (i.e., you have eaten an usually large amount of food *and* have had a sense of loss of control at the time)?	________
16. Over the past 28 days, how many *times* have you made yourself sick (vomit) as a means of controlling your shape or weight?	________
17. Over the past 28 days, how many *times* have you taken laxatives as a means of controlling your shape or weight?	________
18. Over the past 28 days, how many *times* have you exercised in a "driven" or "compulsive" way as a means of controlling your weight, shape or amount of fat, or to burn off calories?	________

Questions 19-21: Please circle the appropriate number. Please note that for these questions the term “binge eating” means eating what others would regard as unusually large amount of food for the circumstances, accompanied by a sense of having lost control over eating.

19. Over the past 28 days, on how many days have you eaten in secret (i.e., furtively)?... Ignore episodes of binge eating	No days 0	1-5 days 1	6-12 days 2	13-15 days 3	16-22 days 4	23-27 days 5	Every day 6
20. On what proportion of the times that you have eaten have you felt guilty (felt that you've done wrong) because of its effect on your shape or weight? …. Ignore episodes of binge eating	None of the time 0	A few of the times 1	Less than half 2	Half of the times 3	More than half 4	Most of the time 5	Every time 6
21. Over the past 28 days, how concerned have you been about other people seeing you eat?... Ignore episodes of binge eating	Not at all 0	1	Slightly 2	3	Moderately 4	5	Markedly 6

Questions 22- 28: Please circle the appropriate number on the right. Remember that the questions refer to the past 4 weeks (28 days) only.

On how many of the past 28 days….	**Not at all**		**Slightly**	**Moderately**		**Markedly**	
22. Has your weight influenced how you think about (judge) yourself as a person?	0	1	2	3	4	5	6
23. Has your *shape* influenced how you think about (judge) yourself as a person?	0	1	2	3	4	5	6
24. How much would it have upset you if you had been asked to weigh yourself once a week (no more, or less, often) for the next 4 weeks?	0	1	2	3	4	5	6
25. How dissatisfied have you been with your *weight*?	0	1	2	3	4	5	6
26. How dissatisfied have you been with your *shape*?	0	1	2	3	4	5	6
27. How uncomfortable have you felt seeing your body (for example, seeing your shape in the mirror, in a shop window reflection, while undressing or taking a bath or shower)?	0	1	2	3	4	5	6
28. How uncomfortable have you felt about *others* seeing your shape or figure (for example, in communal changing rooms, when swimming, or wearing tight clothes)?	0	1	2	3	4	5	6

THANK YOU

ABSTRACT

The female athlete triad (F.A.T) consists of disordered eating, amenorrhea, and osteoporosis (American College of Sports Medicine, 1997). The findings of Thompson and Gabriel (2004) emphasize that this triad is prevalent in all female exercisers and not solely athletes. The purpose of this study was to examine the three F.A.T. components in competitive and non-competitive swimmers and runners. Twenty-one women were recruited, and were divided into either non-competitive runners & swimmers (NR & NS) or competitive runners & swimmers (CR & CS). Participants completed the Eating Disorder Examination Questionnaire (EDE-Q 6.0) and a questionnaire about nutrition and osteoporosis knowledge, injury history, and menstrual function. A dual energy x-ray absorptiometry (DEXA) test also measured the participants' bone mineral density (BMD) and body composition. Swimmers overall reported lower leg BMD than runners (1.109 $\pm$ 0.125 vs. 1.158$\pm$ 0.108 g/cm^2). Competitive athletes reported more menstrual dysfunction (7.0 $\pm$ 5.099 vs. 11.2 $\pm$ 1.1687 cycles/yr). The small sample size (n=21) was a limitation to finding more significant data but some trends were also found. Overall, competitive athletes showed greater risk for the F.A.T. than their non-competitive peers because the greater training load may have interfered with optimal bone metabolism.