Changes in Knowledge of the Female Athlete Triad among Female High School Athletes Following a Brief Nutrition Education Intervention

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Authorization to Submit Thesis

This thesis of Rachel Krick, submitted for the degree of Master of Science with a major in Family and Consumer Sciences and titled "Changes in Knowledge of the Female Athlete Triad among Female High School Athletes Following a Brief Nutrition Education Intervention" has been reviewed in final form. Permission, as indicated by the signatures and dates below, is now granted to submit final copies to the College of Graduate Studies for approval.

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Abstract

The Female Athlete Triad (Triad) is a disorder comprised of three conditions: low energy availability, menstrual irregularity, and decreased bone mineral density. Triad prevalence is high among high school athletes, though their knowledge of the disorder is low.

This study aimed to determine whether viewing a nutrition education video including Registered Dietitians describing Triad etiology, progression, and prevention, as well as testimonies of former college athletes who experienced the Triad would change knowledge of the Triad among female high school athletes.

Ninety-three female athletes (15.89 ± 1.2 years) from four North Idaho high schools consented to participate. Following randomization to the intervention or control group, all participants completed a pre-survey with ten Triad knowledge questions highlighting Triad risk factors and consequences. Each question was answered using a Likert scale ("strongly disagree" to "strongly agree"). The intervention group ($n = 46$) then viewed the nutrition education video, while the control group ($n = 44$) played a nutrition game in another room. Immediately after, all participants completed a post-survey containing the same ten Triad knowledge questions. Correct responses received one point; each participant received a score out of ten on each survey. Results of Mann-Whitney U tests revealed that pre-survey Triad knowledge scores between groups were similar, though post-survey scores were significantly higher among the intervention group as compared to the control (mean rank 64.07 vs. 26.09 respectively; U = 158.00; $p < 0.001$). The Triad video may be considered for use in high school athletic programs to increase Triad knowledge among female athletes.

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Dedication

To the woman who sparked a fire in my heart and continued to fuel my passion for learning up until the very end, I thank you. Your introduction to this field that I love and the unwavering support you provided along the way played a monumental role in my education and in my life, and if it weren't for you I would have never discovered my greatest potential.

Your legacy is one I will never forget. I dedicate this work to you and your memory.

Rest in peace Samantha Anne Ramsay.

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List of Abbreviations

ACRM American College of Reproductive Medicine

ACSM American College of Sports Medicine

BMD Bone Mineral Density

DE Disordered Eating

DSM-V Diagnostic Statistical Manual of Mental Disorders, fifth edition

DXA Dual-energy X-ray Absorptiometry

EA Energy Availability

EAT-26 Eating Attitudes Test

ED Eating Disorder

EDE-Q Eating Disorders Examination Questionnaire

GnRH Gonadotropin Releasing Hormone

IOC International Olympic Committee

ISCD International Society of Clinical Densitometry

LEAF-Q Low Energy Availability in Females Questionnaire

LH Luteinizing Hormone

MI Menstrual Irregularity

PPE Pre-participation Physical Exam

RDN Registered Dietitian Nutritionist

Triad Female Athlete Triad

Chapter One

Introduction

Female participation in high school athletics is at an all-time high. Since the enactment of Title IX, an Education Amendment requiring schools to offer members of both sexes equal opportunities to play sports, the number of female athletes playing at the high school level has exploded by over 1,000% (National Federation of State High School Associations, 2017). Prior to 1972 when Title IX was introduced, just 300,000 adolescent females participated in high school athletics in the US, a fraction of the 3,300,000 girls who play today (Kennedy, 2010).

Adolescent females may experience a variety of physical, mental, and social benefits from sport participation. Regular physical activity is associated with a decreased risk of developing several chronic medical conditions including obesity, heart disease, type II diabetes, hypertension, and breast cancer (National Women's Law Center, 2017a; Warburton & Bredin, 2006). Physical activity is strongly related to the self-perceived health in adolescents; emotionally, female athletes benefit from higher self-esteem, increased confidence, and higher competence (Eime, Young, Harvey, Charity, & Payne, 2013; National Women's Law Center, 2017b; Stallings, 1997; Warburton & Bredin, 2006). At the high school level especially, some social benefits of playing sports may include making new friends, learning discipline and time management, and developing teamwork skills (Eime et al., 2013). Research also shows that girls who participate in sports are less likely to smoke or use drugs (National Women's Law Center, 2017a; Women's Sports Foundation, 2009). For these reasons, and many others, participation in high school athletics can be a positive experience for adolescent girls.

Considering the number of benefits provided by high school sport participation it is no wonder girls' participation is on the rise, though one aspect of athletics that is rarely taken into consideration is the integral role of nutrition to an athlete's performance (Morgan, 1984; Petrie, Stover, & Horswill, 2004). In general, athletes need to consume enough energy through food to maintain their competitive edge. However, female athletes' increased energy requirements due to rapid growth and pubertal development during adolescence are often overlooked (Manore, 1999; Stallings, 1997). Adolescence is a time of physical growth occurring at a faster rate than any other period other than the fetal phase or the first year of life (Morgan, 1984). Fifty percent of adult weight is gained during adolescence, along with 50% of skeletal mass and 20% of adult height (Greydanus & Patel 2002; Wahl, 1999). Often the most drastic of these changes is the weight gained in this short period of time; female adolescents may gain up to 30 kg during puberty, nearly doubling their weight over a seven-year period (Morgan, 1984; Wahl, 1999). For girls, peak energy requirements occur during early adolescence (age 12-14 years), around the time their bodies experience the most biological change (Wahl, 1999). During this time, nutrition is of upmost importance to the female athlete due to the interactions between energy intake, normal growth and development, achieving optimal performance, and avoiding injuries and problems related to nutritional deficiencies (Petrie et al., 2004; Stallings, 1997; Wahl, 1999).

Nutrition-related issues that surface among adolescent athletes often have to do with inadequate energy and micronutrient intake (Stallings, 1997; Wahl, 1999). Without proper nutrition to replenish the energy expended during regular sport participation, adolescent female athletes are at risk of developing one or more conditions of a serious disorder called the Female Athlete Triad (Triad). The Triad refers to the interrelationships among energy availability (EA), menstrual function, and bone mineral density (BMD) (Nattiv et al., 2007). The first component, EA, is defined as the amount of dietary energy remaining for usual body function after accounting for energy lost during exercise training (Nattiv et al., 2007). Adequate EA can be achieved by consuming greater than 45 calories per kilogram of fat free mass (FFM) (Hoch et al., 2009; Nattiv et al., 2007). When athletes fail to consume adequate energy to sustain increased physical activity demands, as well as normal day-to-day activities, they may put themselves in a state of low EA, defined as the consumption of less than 30 kcals/kg FFM. Reduced EA and low EA may occur with or without disordered eating (DE) or an eating disorder (ED) (Nattiv et al., 2007). One consequence of low EA is the suppression of reproductive hormones, including estrogen, which may result in the disruption of normal menstrual function, referred to as menstrual irregularity (MI) (Nattiv et al., 2007). Estrogen plays a major role in calcium absorption and bone mineralization, helping to ensure normal bone growth and maintenance (Greydanus & Patel, 2002; Manore, 1999), thus in the absence of normal estrogen levels young female athletes may develop low BMD (Manore, 1999; Nattiv et al., 2007). Alone or in combination, low EA, MI, and low BMD pose serious risk to the health of the female athlete (Nattiv et al., 2007; Thein-Nissenbaum, 2013). In more serious cases of the Triad, female athletes may exhibit clinical EDs, amenorrhea, and/or osteoporosis (Greydanus Omar, & Pratt, 2010; Nattiv et al., 2007).

The first condition of the Triad, low EA, may develop as a result of unintentional consumption of too few calories, or intentional weight control behaviors associated with an ED or subclinical and clinical DE. EDs are diagnosed by Licensed Psychologists based on the Diagnostic Statistical Manual of Mental Disorders, Fifth Edition (DSM-V) criteria (American Psychiatric Association, 2013). Research studies primarily report prevalence of

DE based on participant responses to the Eating Attitudes 26 (EAT-26) or Eating Disorders Examination Questionnaire (EDE-Q) (Gibbs, Williams, & DeSouza, 2013; Martinsen & Sundgot-Borgen, 2013; Pernick et al., 2006; Rauh, Nichols, & Barrack, 2010; Thein-Nissenbaum & Carr, 2011a; Thein-Nissenbaum et al., 2011b). Subclinical DE behaviors include dietary restraint and pathogenic weight control behaviors such as fasting, binge-eating and purging, or use of diet pills, laxatives, diuretics, or enemas in attempts to lose weight (Sundgot-Borgen, 1993). Previous studies report the prevalence of subclinical DE among female high school athletes to range between 6.2 – 52.0% (Barrack et al., 2014; Beals, 2002). Clinical DE is often classified by a score of greater than 4.0 on the EDE-Q. Among adolescent female athletes, the prevalence of clinical DE ranges from 10.0 – 44.7% (Nichols, Rauh, Lawson, Ji, & Barkai, 2006; Nichols, Rauh, Barrack, & Barkai, 2007; Pernick et al., 2006; Rauh, Nichols, & Barrack, 2010; Thein-Nissenbaum, & Carr, 2011a; Thein-Nissenbaum et al., 2011b).

In the absence of adequate EA the female body suppresses reproductive hormone production, often resulting in MI (Manore, 1999; Nattiv et al., 2007). Due to the different categorizations of MI, prevalence estimates vary among populations of female high school athletes. Hoch et al. (2009) found the prevalence of MI to be as high as 54.0% among adolescent female athletes ($N = 80$, 16.53 ± 0.95 years). Athletes who experience MI are at an increased risk of developing low BMD. Previous studies indicate that 3.0 – 28.0% of adolescent female athletes are in a state of low BMD (Barrack, Rauh, & Nichols, 2008; Barrack et al., 2014; Hoch et al., 2009; Nichols et al., 2006; Rauh et al., 2010). Prevalence of low BMD is often lower than the other two Triad conditions because bone density may not be affected by low EA for a year or longer (Nattiv et al., 2007).

Cases of the Triad have been observed for decades among collegiate and professional female athletes, though more recently conditions of the Triad have been discovered among female athletes at the high school level (Gibbs, Williams, & De Souza, 2013; Hergenroeder, De Souza, & Anding, 2015; Thein-Nissenbaum & Carr, 2011a). As many as 54.0% of high school athletes present with at least one condition of the Triad (Hoch et al., 2009; Nichols et al. 2006), and another 4.0 – 18.0% have a combination of any two conditions (Hoch et al., 2009; Nichols et al., 2006; Nichols et al., 2007; Thein-Nissenbaum & Carr, 2011a; Thein-Nissenbaum et al., 2011b). Between 1.0 – 1.2% of female high school athletes are experiencing all three conditions of the Triad, simultaneously (Hoch et al., 2009; Nichols et al., 2006). The lower prevalence of athletes with all three conditions is likely due to the low incidence of low BMD among this population (Nattiv et al., 2007).

The current literature illustrates significant prevalence of Triad conditions among female high school athletes, though research suggests that knowledge of the disorder is notably low among the female athlete population (Brown, Wengreen, & Beals, 2014; Feldmann, Belsha, Eissa, & Middleman, 2011). Feldmann et al. (2011) reported minimal understanding of the connection between menstrual status and bone health among female athlete (N = 103, 14-18 years), with participants receiving an average summative knowledge score of one out of six. More than 90.0% of athletes responded incorrectly to questions regarding the consequences of bone loss and the link to menstrual status. Those reporting MI (n = 32, 31.0%) had significantly lower knowledge scores than those experiencing normal menstruation (p = 0.035). Brown et al. (2014) also reported low knowledge scores among female high school athletes (14-18 years). Of the 170 athletes, only nine had heard of the Triad and none could correctly list the three Triad conditions. Out of a possible eight, the mean Triad knowledge score among all participants was 2.97 ± 1.61 points. These two studies demonstrate an alarming lack of Triad knowledge among adolescent female athletes.

Nutrition education interventions prove successful in improving Triad knowledge and perceived susceptibility to the Triad among female athletes (Brown, Wengreen, Beals, & Heath, 2016; Day, Wengreen, Heath, & Brown, 2015; Doyle-Lucas & Davy, 2011). For example, Brown et al. (2016) reported improvements in Triad knowledge scores among female high school track athletes ($N = 29$, 14-18 years) after their participation in a peer-led, multi-session Triad education intervention (Pre: 4.72 ± 2.6; Post:7.68 ± 1.79, $p = 0.03$). On average, participants attended three out of the four sessions. Athletes who attended three to four sessions had higher knowledge compared to those who attended only one or two sessions (8.0 ± 1.5 vs. 6.4 ± 2.1, $p = 0.03$). Day et al. (2015) determined that among 25 collegiate track athletes (19.5 ± 1.8 years), the number of participants who could correctly name two of the three Triad conditions increased from six (24.0%) to thirteen (52.0%) following a multi-session nutrition education intervention led by a Registered Dietitian Nutritionist (RDN). Doyle-Lucas & Davy (2011) reported increased perceived susceptibility to the Triad among adolescent dancers (13-18 years) who participated in an educational intervention in the form of a DVD lecture series. Dancers were divided into an intervention group ($n = 231$) and a control group ($n = 90$); the intervention group participated in the nutrition education program, while the control participants did not. Total Triad perceived severity scores among the intervention group showed great improvement (Pre: 7.7 ± 0.1; Post: 8.7 ± 0.1, $p \leq 0.05$) in comparison to the control group (Pre: 7.6 ± 0.2; Post: 7.7 ± 0.2, $p \leq 0.05$). Each of these three studies implemented a multi-session nutrition education intervention; both Day et al. (2015) and Brown et al. (2016) reported athletes missing one or more sessions as a limitation. Only two sports were represented (track and dance), and adolescent athletes were the focus in only two of the three studies. More research is needed to determine the best form of education to teach female athletes about the Triad early on.

Problem Statement

Existing research reveals that prevalence of the Triad is high among female high school athletes, though knowledge of the disorder is low among this population. With little to no knowledge of the Triad or its implications, adolescent female athletes may not be prepared to prevent the severe health consequences of this disorder.

Previous studies demonstrate success in using educational interventions to improve Triad knowledge among female athletes, though persuading athletes to attend multiple sessions was reported as a limitation. There is a need for condensed, single-session nutrition education interventions so that athletes may learn about the Triad without the time commitment of a multi-session intervention.

Triad knowledge has been assessed among female athletes in the past, though these studies involved small sample sizes, and did not utilize a control group. The athletes recruited were from limited populations and did not cover a wide variety of sports. Future research should aim to increase sample size, broaden sport representation, and include the use of a control group in examining Triad knowledge among female high school athletes.

Statement of Purpose

The purpose of this study was to assess Triad risk and change in knowledge of the Triad among female high school athletes, after viewing a brief nutrition education video.

Research Question

Will Triad conditions exist among female high school athlete participants? To what extent will Triad knowledge scores improve among female high school athletes following participation in a brief Triad educational intervention, in comparison to Triad knowledge scores observed among a control group?

Significance of Study

Previous research shows that knowledge of the Triad among female high school athletes is low (Brown et al., 2016; Feldmann et al., 2011), though combinations of Triad conditions are prevalent among this population (Barrack et al., 2008; Barrack et al., 2014; Beals, 2002; Brown et al., 2014; Hoch et al., 2009; Martinsen & Sundgot-Borgen, 2013; Nichols et al., 2006; Nichols et al., 2007; Pernick et al., 2006; Rauh et al., 2010). Due to the severe negative health consequences of the Triad, along with the lack of Triad knowledge among adolescent female athletes, it is imperative that an effective method of delivering Triad education to female high school athletes is utilized to increase knowledge of the disorder and its implications.

Nutrition education interventions are successful in improving Triad knowledge among female athletes at both the high school and collegiate level (Brown et al., 2016; Day et al., 2015; Doyle-Lucas & Davy, 2011). Among these few studies, limitations included limited sport representation, lack of a control group, and difficultly in persuading athletes to attend multiple sessions. The present study aims to include athletes from a variety of sports, and the use of a control group. The current intervention will also be sensitive to participant time by only requiring ten minutes for completion of the study.

Limitations

All data was self-reported by athlete participants, thus only inferences can be made. This research study did not scientifically measure EA, menstrual function, or BMD; thus, these risk factors were only assessed by predictions made based on participants' responses to provided survey questions. In addition, change in behavior (calorie consumption, etc.) was also not assessed in this study.

A final limitation of the present study is that knowledge of the Triad was not assessed beyond the immediate post-intervention survey, thus this study can only conclude whether there was instantaneous knowledge gain post-intervention. The results of this study cannot infer that the athletes retained this knowledge following the post-intervention survey.

Summary

In absence of proper nutrition to support the energy expended during sport participation, adolescent female athletes are at risk for developing one or more conditions of a serious disorder called the Triad. The three conditions that make up the Triad include low EA, MI, and/or low BMD (Nattiv et al., 2007). Manifestations of Triad conditions are prevalent among female high school athletes (Barrack et al., 2008; Barrack et al., 2014; Beals, 2002; Brown et al., 2014; Hoch et al., 2009; Martinsen & Sundgot-Borgen, 2013; Nichols et al., 2006; Nichols et al., 2007; Pernick et al., 2006; Rauh et al., 2010; Thein-Nissenbaum & Carr, 2011a; Thein-Nissenbaum et al., 2011b), though knowledge of the disorder is low (Brown et al., 2016; Feldmann et al., 2011). The significant health consequences of the Triad underscore the critical need for prevention (Nattiv et al., 2007).

Nutrition education interventions are effective in increasing Triad knowledge and perceived susceptibility to the Triad among female athletes at the high school and collegiate level (Brown et al., 2016; Day et al., 2015; Doyle-Lucas & Davy, 2011). Matters such as small sample sizes, unrepresented sport types, lack of the use of a control group, and athletes not attending all educational sessions have been reported as limitations among these studies. Therefore, further research is needed to address these limitations and to expand upon the limited research regarding Triad education for female high school athletes.

The aim of the present study was to assess initial knowledge of the Triad among female high school athletes and to then evaluate changes in Triad knowledge after viewing a single, ten-minute educational video. The video includes footage of a RDN describing Triad etiology and progression, perspectives of former college athletes who experienced the Triad, and a RDN discussing fueling strategies to reduce Triad risk.

The first chapter of this thesis includes the introduction, problem statement, research questions, significance of study, and limitations of the study. Chapter two provides a review of the current literature on Triad etiology, prevalence of Triad conditions among female high school athletes, knowledge of the Triad among female high school athletes, and the effectiveness of previous nutrition interventions in improving Triad knowledge and perceived susceptibility to the Triad. The third chapter describes the implementation and evaluation of the educational Triad video intervention in the following sections: introduction, methodology, results, discussion, and implications for future research.

Chapter Two

Literature Review

In order to maintain a healthy body weight and preserve normal body function, female athletes participating in sports at all levels must consume enough dietary energy to withstand the energy costs of daily living, regular physical activity, and body functions including tissue repair, muscle building, and menstrual function (Manore, 1999; Nattiv et al., 2007). Adequate energy consumption is also key to maintaining a competitive edge during training and competition, though many female athletes either have a desire to lose weight, or insufficient understanding of their energy needs, resulting in the consumption of too few calories (Manore, 1999). In the absence of adequate energy intake to support a female athlete's increased exercise energy expenditure, a repartitioning of energetic fuels occurs in which energy is directed away from growth and reproduction, often resulting in menstrual disturbances and bone loss (Nattiv et al., 2007). These health consequences are the result of a serious disorder known as the Female Athlete Triad (Triad).

The Triad refers to a disorder made up of three interrelated conditions: low energy availability (EA) with or without disordered eating (DE), menstrual irregularity (MI), and low bone mineral density (BMD) (Nattiv et al., 2007). The relationships among these conditions are due to low EA increasing a female athlete's risk of experiencing menstrual dysfunction, which can initiate bone loss (Nattiv et al., 2007). The Triad is considered a spectrum disorder; each of the three conditions of the Triad represent the pathological end of the spectrum which ranges from optimal health (optimal EA, normal ovulatory menstrual cycles, and optimal bone health) to disorder (low EA with or without DE, amenorrhea, and osteoporosis) (Nattiv et al., 2007). Each of the three Triad components move along the spectrum at different rates according to the athlete's diet and exercise habits. Changes can occur daily when considering energy status, but an effect on menstrual function may not become evident for a month or more, and an effect on BMD may not be detectable for nearly a year (Nattiv et al., 2007).

The Triad occurs in physically active females who exercise regularly without increasing dietary energy intake, who severely restrict their diet, or who practice pathogenic weight control behaviors (Nattiv et al., 2007; Sundgot-Borgen, 1993). Females who participate in certain sports are at a higher risk of experiencing health issues related to EA, due to the increased pressure to maintain a certain size or weight. Sports emphasizing a lean appearance may include swimming, diving, gymnastics, dance, cheerleading, and long-distance running (Greydanus, Omar, & Pratt, 2010). Females participating in these specific sports are more likely to adopt abnormal eating patterns due to the often-unachievable aesthetic goals set by their chosen sport (Greydanus et al., 2010). Those at the highest risk of developing conditions of the Triad are athletes having recently increased their exercise regimen, or those who have demonstrated recent weight loss (Witkop & Warren, 2010).

Low Energy Availability

Low Energy Availability Background. Low EA is the first of component of the Triad and the mechanistic factor underlying the other two Triad conditions (Loucks & Thuma, 2003; Nattiv et al., 2007). The American College of Sports Medicine (ACSM) Position Stand on the Triad defines EA as "the dietary energy remaining to sustain bodily function after accounting for energy lost in exercise training", otherwise defined as dietary energy intake minus exercise energy expenditure (Nattiv et al., 2007). EA is normally reported as calories per kilogram of fat free mass (FFM), lying on a spectrum from optimal

EA (≥ 45 kcals/kg FFM) to low EA (≤ 30 kcals/kg FFM), with or without DE (Hoch et al., 2009; Nattiv et al., 2007).

Low EA may develop as a result of unintentional consumption of too few calories, or intentional weight control behaviors associated with an eating disorder (ED) or subclinical and clinical DE. EDs are diagnosed by Licensed Psychologists based on the Diagnostic Statistical Manual of Mental Disorders, Fifth Edition (DSM-V) criteria (American Psychiatric Association, 2013). Diagnosed ED may include anorexia nervosa (AN), bulimia nervosa (BN), or eating disorder not otherwise specified (ED-NOS). AN is defined as an ED characterized by severe restrictive eating in which the individual views herself as overweight and is fearful of gaining weight, even though she is at least 15.0% below expected weight for age and height (Chavez & Insel, 2007). BN is an ED in which individuals, usually within a normal weight range, repeat a cycle of overeating or binge-eating and then purging (vomiting) or complying to other compensatory behaviors such as fasting or excessively exercising (Chavez & Insel, 2007). Individuals who do not meet all criteria for AN or BN are classified as having an ED-NOS (Chavez & Insel, 2007). Severity of DE behaviors can be determined by completing the Eating Disorders Examination Questionnaire (EDE-Q) (Gibbs, Williams, & DeSouza, 2013; Martinsen & Sundgot-Borgen, 2013; Pernick et al., 2006; Rauh, Nichols, & Barrack, 2010; Thein-Nissenbaum & Carr, 2011a; Thein-Nissenbaum et al., 2011b). The EDE-Q assesses the core pathology of DE behaviors such as limiting type and/or amount of food, using laxatives, or forcing oneself to vomit after eating, within a time frame of the preceding four weeks (Carter, Stewart, & Fairburn, 2001). EDE-Q scores ranging between one and two are considered normal, scores between three and four are consistent with subclinical severity of DE, and a score greater than four is considered to be of clinical severity (Carter et al., 2001).

During adolescence, girls acquire twice as much body fat as boys, with an increase of 23.0 – 27.0% in comparison to a boy's 13.0 – 15.0% (Greydanus & Patel, 2002). This accumulation of fat mass over a short period of time adds additional pressure felt by girls to be thin, often resulting in unhealthy eating and dieting behaviors (Skemp-Arlt, 2006). Pubertal female adolescents become self-conscious about their appearance; a girl's self-esteem is often strongly tied to her weight and shape, and many adolescent girls consider themselves to be fat (Skemp-Arlt, 2006). Body dissatisfaction and body image distortion each peak during adolescence, and 42.0 – 55.0% of girls are dissatisfied with their weight (Skemp-Arlt, 2006). Societal standards in America teach girls from a young age that it is unacceptable to be overweight and that they must look a certain way in order to fit in (Skemp-Arlt, 2006). Much of the female population in America faces similar pressure, though for female athletes the pressure is twofold; in addition to the burden of sociocultural demands placed on women to be lean, female athletes are also expected to meet weight and aesthetic standards for their sport (Manore, 1999). Self-esteem issues rise from this pressure to be lean, often resulting in an obsession with weight (Skemp-Arlt, 2006).

Low Energy Availability Etiology. The incidence of low EA in the female athlete may be due to varying factors. Some athletes fail to recognize their body's increased energy needs in relation to their energy expenditure, thus they may inadvertently not consume enough calories. There are also cases in which athletes intentionally reduce their EA by decreasing their energy intake or increasing their energy expenditure, in attempts to control their weight (Sundgot-Borgen, 1993; Witkop & Warren, 2010). The reasoning behind wanting to lose weight is exclusive to the individual athlete, though female athletes often feel pressure from their coaches, their parents, their peers, and themselves to weigh less (Brown, Wengreen, & Beals, 2014; Manore, 1999). Due to the central role that coaches often play in the development of female athletes, their influence often extends to matters of weight management, body image, and diet (Beckner & Record, 2016). The way in which coaches approach conversations regarding weight often has much to do with how female athletes internalize messages about weight management (Biesecker & Martz, 1999). It's not uncommon for coaches of competitive sports to regularly address body fat, body weight, and weight loss, though negative remarks can cause athletes to develop distorted body images and/or unhealthy eating habits (Heffner, Ogles, Gold, Mardsen, & Johnson, 2003). For example, athlete participants in a study by Beckner and Record (2016) reported feeling that their coaches' communication regarding body image and health decisions had a vital impact on how the they perceived their own athletic abilities, and that the communication surrounding these issues lacked any real guidance. Athletes were told to simply 'lose weight,' without any sort of direction as to how they were supposed to go about achieving weight loss (Beckner & Record, 2016). Though coaches typically aren't directly encouraging athletes to engage in harmful eating behaviors, with such strong emphasis placed on decreasing body weight female athletes may resort to DE in order to meet the coach's demands (Heffner et al., 2003).

Short-term periods of dieting for weight loss present few risks to the long-term health of the female athlete, though dieting or intentionally using extreme weight loss practices while expending high amounts of energy due to sport participation may result in severe health consequences (Manore, 1999). Unhealthy eating patterns include DE behaviors and, in some cases, serious clinical EDs such as AN or BN (American Psychiatric Association, 2006, Skemp-Arlt, 2006). In the United States, clinical EDs have become the third most common chronic illness among adolescents, which can have both acute and chronic health consequences (Skemp-Arlt, 2006). Acute consequences of EDs include fatigue, decreased academic performance, and impaired growth related to decreased intake of important nutrients such as calcium and iron (Skemp-Arlt, 2006). Chronic health implications of EDs include severe malnutrition, starvation and in some cases, death (Skemp-Arlt, 2006). DE behaviors also promote nutritional deficiencies and abnormal exercise patterns among female athletes, often resulting in serious health consequences (Greydanus et al., 2010). Female athletes experiencing DE often endure psychological problems such as low self-esteem, depression, and anxiety disorders, as well as medical complications of the cardiovascular, endocrine, reproductive, skeletal, gastrointestinal, renal, and central nervous systems (Rome et al., 2003).

Low Energy Availability Prevalence. Likely due to the laborious and multifaceted data collection required (dietary intake, exercise energy expenditure, and body composition), there are very few studies to date that measured EA among female high school athletes. Hoch et al. (2009) reported that among 80 female high school athletes (16.53 ± 0.95 years) 36.0% were consuming insufficient energy (≤ 45 kcal/kg FFM), with 6.0% of athletes in a state of low EA, consuming ≤ 30 kcal/kg of FFM/day (low EA). Among a sample of 23 female adolescent volleyball players (15.8 ± 1.1 years), Beals (2002) determined that mean energy intake was less than mean energy expenditure (2,248 ± 414 kcals intake; 2,815 ± 306 kcals expenditure), suggesting that the athletes were in a state of low EA. Because EA is so challenging to measure among athletes, risk for EDs and DE is much more commonly assessed among female athletes.

Prevalence of Eating Disorders. Much of the literature available in regard to EDs among female athletes reports prevalence among adult elite athletes, though one study investigated prevalence of EDs among adolescent female athletes. Martinsen and Sundgot-Borgen (2013) determined that among 102 female adolescent athletes (16.5 ± 0.3 years), 96 (94.1%) were classified as being 'at risk' of ED based on questionnaire data. Of these 96 female athletes, 24 (25.0%) fulfilled DSM-IV criteria for ED after participation in clinical interviews (Martinsen & Sundgot-Borgen, 2013). Of those 24 athletes, 20 (83.3%) were diagnosed with EDNOS, seven (29.2%) were diagnosed with BN, and one (2.2%) was diagnosed with AN (Martinsen & Sundgot-Borgen, 2013). Those diagnosed with an ED received a higher score on the EDE-Q than their healthy athlete counterparts (Martinsen & Sundgot-Borgen, 2013). The significant prevalence of ED among female adolescent athletes in this study alone underscores the substantial potential for the development of Triad conditions among female athletes at the high school level.

Prevalence of Disordered Eating. Studies measuring incidences of subclinical DE behaviors report that 6.2 – 52% of adolescent female athletes actively practice dietary restraint and/or pathogenic weight control measures (Barrack et al., 2014; Beals, 2002; Nichols et al., 2006; Pernick et al., 2006; Rauh et al., 2010; Thein-Nissenbaum & Carr, 2011a). Barrack et al. (2014) determined that among 259 female athletes (18.1 ± 0.3 years), 27.8% of athletes were practicing dietary restraint, and 6.2% were practicing pathogenic weight control behaviors at the time of the study. Other studies have determined similar results, for example, Beals (2002) determined that among a sample of female adolescent volleyball players (N = 23, 15.8 ± 1.1 years), 22.0% were actively restricting energy intake to control their weight, and 52.0% were limiting the types and amounts of food they consumed (see Table 2.1). During the study, over half (52.0%) of the adolescent athletes indicated that they wished to lose weight (Beals, 2002).

Multiple studies designed to determine Triad prevalence among female high school athletes have measured clinical DE prevalence using EDE-Q scores. Rauh et al. (2010) and Nichols et al. (2006) used the EDE-Q to identify DE behaviors among female high school athletes (score ≥ 4.0 on EDE-Q), and discovered that 16.0% (n = 163, 15.7 ± 1.3 years) and 18.2% (n = 170, 15.7 ± 1.3 years) of athlete participants met the criteria for clinical DE, respectively. Thein-Nissenbaum et al. (2011b) reported an even higher prevalence of clinical DE. Among 311 female high school athletes (15.4 ± 1.2 years), 35.4% (n = 110) were practicing clinical DE, based on their EDE-Q score (see Table 2.1). These findings are concerning due to the fact that female athletes who suffer from DE double their risk of developing a sports-related injury (Thein-Nissenbaum, 2013), and are at a greater risk for the development of osteopenia and osteoporosis (Hergenroeder et al., 2015).

Table 2.1: Prevalence of DE and EDs among Female High School Athletes

Authors	*N*	Prevalence of Subclinical DE (%)	Prevalence of Clinical DE (%)	Prevalence of EDs (%)
Barrack et al. (2014)	259	6.2-27.8	NR	NR
Beals (2002)	23	22.0-52.0	NR	NR
Martinsen et al. (2013)	677	NR	NR	AN: 4.2 BN: 29.2 EDNOS: 83.3
Nichols et al. (2006)	170	NR	10.0-18.2	NR
Pernick et al. (2006)	453	NR	19.6	NR
Rauh et al. (2010)	163	NR	16.0	NR
Thein-Nissenbaum et al. (2011)	311	NR	35.4	NR

NR, data not reported.

Menstrual Irregularity

Menstrual Irregularity Background. The second component of the Triad is MI. Menstrual function lies on a spectrum from eumenorrhea (regular menstruation) to amenorrhea (abnormal or nonexistent menstruation) (Nattiv et al., 2007). The hypothalamus and pituitary gland play imperative roles in menstrual regulation. In a normally functioning reproductive system, regular menstruation is influenced by the activation of the hypothalamic-pituitary-ovarian (HPO) axis of the brain (Greydanus et al., 2010; Stafford, 2005). The release of pulsatile secretions of gonadotropin releasing hormone (GnRH) from the hypothalamus stimulates the production and release of gonadotropins, luteinizing hormone (LH), and follicle-stimulating hormone (FSH) from the pituitary gland (Loucks & Thuma, 2003; Stafford, 2005; Warren & Chua, 2008). Upon release, gonadotropins stimulate estrogen, progesterone, and testosterone production by the ovaries (Stafford, 2005; Yen, 1998), thus ovarian function relies on the pulsatile release of GnRH from neurons in the hypothalamus and pulsatile release of LH and FHS from the pituitary gland (Warren & Chua, 2008; Loucks & Thuma, 2003; Stafford, 2005).

Menstrual cycles consist of three phases: a follicular phase, an ovulatory phase, and a luteal phase (Stafford, 2005; Yen, 1998). The follicular phase is comprised of follicle growth, oocyte (immature egg cell) maturation, and peak estradiol secretion (Yen, 1998). Next is a brief ovulatory phase, which includes a surge of LH from the pituitary gland and the initiation of final oocyte maturation, oocyte release, and the creation of the uterine endometrium (mucus membrane lining the uterus) in preparation for possible implantation of an embryo (Stafford, 2005; Yen, 1998). Ovulation follows the surge in LH (Stafford, 2005). Lastly, during the luteal phase, the corpus luteum (temporary, hormone-releasing structure that develops in an ovary following oocyte release) is developed, estradiol and progesterone are secreted, and progesterone secretion peaks a week after ovulation (Stafford, 2005; Yen, 1998). In the absence of a pregnancy, menses occurs as the result of a decline in hormone production from the corpus luteum, and is then followed by the onset of a new follicular phase (Stafford, 2005; Yen, 1998).

Menstrual Irregularity Etiology. Normal follicular development, ovulation, and luteal function can be suppressed if LH pulsatility becomes infrequent or irregular (Loucks and Thuma, 2003; Warren & Chua, 2008). Disrupted LH pulsatility is thought to be an energy-conserving strategy to protect more important biological processes during a period of low EA (Nattiv et al., 2007). A significant decrease in EA results in alterations of the HPO axis in the brain. According to Loucks and Thuma (2003), if a female athlete fails to provide sufficient energy (> 30 kcals/kg FFM) to support the needs of her brain, an unknown mechanism causes a disruption of the GnRH pulse generator of the HPO axis. The suppression of normal GnRH pulsation causes a decrease in pituitary release of FSH and LH, and a subsequent lack of ovarian stimulation and estrogen production (Stafford, 2005). Such disruptions were once hypothesized to be the result of significant declines in body fat related to increased exercise energy expenditure, though it is now understood that diminished LH pulsatility is the result of low EA (Loucks, 2003).

The hormone leptin serves as serving an important linkage between nutritional status and reproduction (Warren & Chua, 2008). Secreted by adipose tissue, leptin is known to be proportional to fat mass and, like GnRH, responds to changes in caloric intake (Warren & Chua, 2008). It has been suggested that leptin serves as a metabolic signal of EA to the HPO axis (Stafford, 2005). Declines in leptin have been observed in response to fasting and dietary restriction, succeeded by similar increases in leptin levels in response to overfeeding or refeeding after energy restriction, all before changes in adiposity could occur (Loucks, 2003). In addition, leptin receptors have been discovered throughout the HPO axis and have shown to be expressed by the hypothalamus and pituitary (Stafford, 2005). Administration of leptin has been found to accelerate GnRH pulsatility in the hypothalamus, and may also have direct stimulatory effects on LH release by gonadotropins (Stafford, 2005; Warren & Chua, 2008). The exact signaling process linking EA and reproduction remains unknown (Stafford, 2005; Warren & Chua, 2008).

Menstrual dysfunction occurs in young female athletes regardless of normal pituitary and ovarian function, but rather as the result of the disruption of the GnRH pulse generator at the hypothalamic level. For this reason, MI is referred to as hypothalamic amenorrhea (Stafford, 2005). Factors such as psychogenic stress, weight changes, undernutrition, and excessive exercise are frequently associated with functional hypothalamic amenorrhea

(Practice Committee of ASRM, 2008). Along the spectrum of menstrual function is oligomenorrhea, defined by menstrual cycles occurring at intervals longer than 35 days apart (Greydanus et al., 2010; Nattiv et al., 2007). Ninety or more days between menses comprises secondary amenorrhea, defined as menstrual cycles lasting longer than three consecutive months (Nattiv et al., 2007; Greydanus et al., 2010). Lastly, the failure to menstruate by the age of 15 is considered primary amenorrhea (Greydanus et al., 2010; Nattiv et al., 2007; Practice Committee of ASRM, 2008). Intense training at a young age may be the cause behind the onset of primary amenorrhea, with a delay in menarche of up to five months for each year of intensive training before the onset of puberty (Greydanus et al., 2010).

Menstrual Irregularity Prevalence. Female athletes, particularly young female athletes, frequently experience MI (Warren & Chua, 2008). According to the American Society for Reproductive Medicine (ASRM), females actively involved in competitive sports have a three-fold risk of developing primary or secondary amenorrhea than those who do not compete (Practice Committee of ASRM, 2008). Greydanus et al. (2010) report that MI affects 10 – 15% of female adolescent athletes, and most affected are those females engaged in sports including distance running, ballet, gymnastics, and cycling.

Prior research indicates prevalence of primary amenorrhea ranging from 1.2 – 11.2% among adolescent female athletes (Barrack, et al., 2014 Brown et al., 2014; Brown, et al., 2016). Though fluctuations in menstruation are normal in the first year after menses (Greydanus et al., 2010), primary amenorrhea is frequently identified among this population. Hoch et al. (2009) reported that among 80 female high school athletes, 6.0% reported their age of menarche to be older than 15 years, classifying them with primary amenorrhea. Brown et al. (2014) also reported the incidence of primary amenorrhea among the adolescent population (N = 170, 14-18 years), in which 2.3% of participants reported a later age of menarche (see Table 2.2). Secondary amenorrhea is prevalent among female high school athletes. Previous research indicates that secondary amenorrhea affects 5.3 – 30.0% of adolescent athletes (Barrack et al., 2008; Beals, 2002; Brown et al., 2014; Brown et al., 2016; Hoch et al., 2009; Nichols et al., 2006). Research by Hoch et al. (2009) determined that 30% of female adolescent athletes (N = 170, 14-18 years) were experiencing secondary amenorrhea. Two other studies concluding similar results determined between 22.9 – 23.0% of female high school athletes were either experiencing secondary amenorrhea at the time of the study, or had a history of secondary amenorrhea (Brown et al., 2014; Brown et al., 2016) (see Table 2.2). The last of the MI pathologies is oligomenorrhea, the prevalence of which has been found to range between 5.4 – 18.0% of female high school athletes (Barrack et al., 2008; Beals, 2002; Hoch et al., 2009; Nichols et al., 2006).

Table 2.2: Prevalence of MI Pathologies among Female High School Athletes

Authors	*N*	Oligo (%)	PA (%)	SA (%)	Oligo + SA	Oligo + PA + SA
Barrack et al. (2008)	93	5.4	3.2	17.2	8.6	25.8
Barrack et al. (2014)	259	NR	11.2	NR	35.5	NR
Beals (2002)	23	13.0	NR	17.0	30.0	NR
Brown et al. (2014)	170	NR	2.3	22.9	NR	NR
Brown et al. (2016)	29	NR	4.0	23.0	NR	NR
Feldmann et al. (2011)	103	NR	NR	NR	15.5	NR
Hoch et al. (2009)	80	18.0	6.0	30.0	48.0	54.0
Nichols et al. (2006)	170	17.1	1.2	5.3	22.4	23.6
Nichols et al. (2007)	161	NR	NR	NR	NR	23.6
Rauh et al. (2010)	163	NR	NR	NR	NR	25.2
Thein-Nissenbaum et al. (2011)	311	NR	NR	NR	18.8	NR

**Oligo = oligomenorrhea, PA = primary amenorrhea, and SA = secondary amenorrhea*

NR, data not reported

Low Bone Mineral Density

Low Bone Mineral Density Background. The third condition of the Triad is low BMD. The spectrum of BMD ranges from optimal bone health to osteoporosis (Nattiv et al., 2007), though the female athlete may be at risk for health complications far prior to reaching the pathological end of the spectrum. Normal skeletal growth consists of the coordinated action of bone formation and resorption to allow bones to expand and lengthen into their adult form (Syed & Khosla, 2005; Weaver et al., 2016). The major hormonal regulator of bone metabolism is estrogen (Khosla, Oursler, & Monoe, 2012). Estrogen plays three major roles in the health of the human skeleton: (i) facilitation of calcium movement into bone, (ii) suppression of bone resorption, and (iii) stimulation of bone formation (Nattiv et al., 2007; Greydanus et al., 2010; Syed & Khosla, 2005). Adequate EA positively influences bone health by preserving eumenorrhea and estrogen production, in turn restraining bone resorption. Bone resorption is defined as the process by which osteoclasts break down the tissue in bones to release minerals, including calcium, into the blood (Syed & Khosla, 2005). Adequate EA preserves levels of hormones and proteins that promote bone formation, such as osteocalcin (OC) and procollagen type I (PICP) (Loucks & Thuma, 2003; Nattiv et al., 2007). During a state of optimal EA and eumenorrhea, bone formation occurs at a faster rate than bone resorption, resulting in healthy bone mineral acquisition (Syed & Khosla, 2005).

Adolescence is a time of rapid growth and maturation, a prime example of which is the vast amount of bone mass gained during this short period of time. Peak bone mass, the maximum bone mass accrued by the end of skeletal maturation, is determined by genetics, nutritional factors, exercise, and hormonal factors (Hergenroeder, De Souza, & Anding, 2015). Peak bone mineral accretion occurs during puberty (Stallings, 2005; Weaver et al., 2016), during which 90.0% of peak bone mass (Laine & Laine, 2013) and 26.0% of adult total body bone mineral is accrued within a two-year period (Nattiv et al., 2007; Weaver et al., 2016). Female athletes are at great advantage, as bone modeling responds positively to mechanical loading (Weaver et al., 2016), often resulting in above average BMD for the athlete's age (Nattiv et al., 2007). Activities that promote increased bone mineral accrual include sports generating high intensity loading forces, such as gymnastics, ballet, and weight lifting (Kohrt, Bloomfield, Little, Nelson, & Yingling, 2014). Higher BMD values have been observed in children who participate in these sports, as compared to those participating in sports such as swimming that are non-weight bearing (Kohrt et al., 2014). The extremely rapid accrual of bone during adolescence opens a window of opportunity for optimizing bone development, though it may also result in vulnerability to the adolescent's bone health (Weaver et al., 2016). Poor reproductive and nutritional health among young females has the potential to compromise bone mass accretion (Warren & Chua, 2008).

Measuring a female athlete's BMD provides an interpretation of her cumulative history of EA and menstrual status, as well as her genetic endowment and exposure to other nutritional, behavioral, and environmental factors (Nattiv et al., 2007). BMD is often measured using dual-energy x-ray absorptiometry (DXA) technology (Kohrt et al., 2004). Normally, BMD scores are expressed as a T-score, though Z-scores are recommended for use in females until they have reached peak bone mass (ISCD Writing Group, 2004). Z-scores are calculated from means and standard deviations from healthy populations matched for age, sex, and ethnicity (ISCD Writing Group, 2004). According to the International Society for Clinical Densitometry (ISCD), Z-scores below -2.0 should be termed 'low bone mineral density for chronological age' in pre-menopausal women (ISCD Writing Group, 2004). Z-scores less than -1.0 in athletic populations should prompt further investigation, and Z-scores below -2.0 indicate severe bone loss (Nattiv et al., 2007).

Low Bone Mineral Density Etiology. The major hormonal regulator of bone metabolism is estrogen (Khosla et al., 2012), and the onset of amenorrhea results in the loss of estrogen production. A deficiency of estrogen results in rapid bone loss, particularly in trabecular bone, which is present in the vertebrae, pelvis, and ultra-distal forearm (Syed & Khosla, 2005). Cortical bone is also lost in response to estrogen deficiency, though at a slower rate (Syed & Khosla, 2005). Bone formation is suppressed once EA falls below 30 kcals/kg FFM/day (Ihle & Loucks, 2002). Energy deficiency exerts a suppressive effect on bone formation whilst estrogenic deficiency contributes to the up-regulation of bone resorption; thus, both contribute independently and synergistically to bone loss (Ihle & Loucks, 2002). Other metabolic factors may influence BMD, such as decreases in leptin (Stafford, 2005). Leptin receptors have been found in bone, implying a potential role of leptin in bone mineral accretion (Stafford, 2005). These findings suggest that estrogen deficiency cannot be the only cause of diminished bone formation (Warren & Chua, 2008).

Low Bone Mineral Density Prevalence. Though less prevalent than the other two Triad conditions, cases of low BMD are present among female high school athletes. Between 3.0 – 28.0% of adolescent female athletes present with low BMD (Z-score ≤ -1.0) (Barrack et al., 2008; Barrack et al., 2014; Hoch et al., 2009; Nichols et al., 2006; Thein-Nissenabum & Carr, 2011a; Thein-Nissenbaum et al., 2011b). Studies utilizing DXA to measure BMD among female high school athletes are listed in Table 2.3. Barrack et al. (2014), Nichols et al. (2006), and Rauh et al. (2010) reported very similar BMD results among female high school athletes during each of their respective studies. They determined between 21.8 – 23.9% of athletes received a Z-score of less than -1.0. In the same three studies, prevalence of athletes receiving a Z-score below -2.0 was reported at 3.9 – 4.3% (Barrack et al., 2014; Nichols et al., 2006; Rauh et al., 2010). Female high school athletes presenting with low BMD are of special concern due to the fact that athletes in general have 5.0 – 15.0% higher BMD than their non-athlete counterparts (Nattiv et al., 2007).

Table 2.3: Prevalence of Low BMD among Female High School Athletes

Authors	*N*	Prevalence of Low Bone Mineral Density	
		(Z-score < -1.0) (%)	(Z-score < -2.0) (%)
Barrack et al. (2008)	93	28	11.8
Barrack et al. (2014)	259	23.9	3.9
Hoch et al. (2009)	80	13.0	3.0
Nichols et al. (2006)	22	21.8	4.1
Rauh et al. (2010)	170	22.1	4.3

Prevalence of Triad Conditions among Female High School Athletes

Multiple studies report many female high school athletes meeting the criteria for at least one, if not multiple components of the Triad (Barrack et al., 2008; Barrack et al., 2014; Beals, 2002; Brown et al., 2014; Hoch et al., 2009; Martinsen & Sundgot-Borgen, 2013; Nichols et al., 2006; Nichols et al., 2007; Pernick et al., 2006; Rauh et al., 2010; Thein-Nissenbaum & Carr 2011a; Thein-Nissenbaum et al., 2011b). The full Triad, or the simultaneous observance of low EA, MI, and low BMD, occurs at a rate of 1.0 – 1.2% in high school athletes (Hoch et al., 2009; Nichols et al., 2006). The prevalence of female high school athletes presenting with any two Triad conditions ranges between 4.0 – 18.0% (Hoch et al., 2009; Nichols et al., 2006; Nichols et al., 2007; Thein-Nissenbaum & Carr, 2011a; Thein-Nissenbaum et al., 2011b). When individual components are evaluated, the prevalence in female high school athletes increases even further (see Table 2.4). Variation between prevalence estimates may be due to differing assessment methods/criteria for classifying Triad components (Nichols et al., 2006; Gibbs et al., 2013).

Table 2.4: Prevalence of Triad Conditions among Female High School Athletes

Authors	*N*	Prevalence of All 3 Conditions (%)	Prevalence of Any 2 Conditions (%)	Prevalence of Any 1 Condition (%)
Hoch et al. (2009)	80	1.0	4.0-18.0	16.0-54.0
Nichols et al. (2006)	170	1.2	5.9	20.0
Nichols et al. (2007)	423	NR	5.9	NR
Thein-Nissenbaum et al. (2011)	311	NR	9.4	NR

NR, data not reported.

Consequences of the Female Athlete Triad

A strong relationship exists between excessive exercise, amenorrhea, and injury among adolescent females (Hergenroeder et al., 2015). Female high school athletes practicing DE behaviors suffer from chronic energy deficit and are twice as likely to sustain an injury, and those with MI are at an even greater risk (Thein-Nissenbaum 2013; Warren & Chua, 2008). High school athletes frequently sustain stress fractures, and stress fracture rates are much higher among female athletes than male athletes (Changstrom, Brou, Khodaee, Braund, & Comstock. 2015). Most stress fractures are sustained in the peripheral skeleton, in particular the upper extremities (Laine & Laine, 2013), potentially due to the fact that rapid bone loss, as a result of MI, occurs particularly in trabecular bone, as is present in the vertebrae, pelvis, and ultra-distal forearm (Syed & Khosla, 2005). Excessive exercise in combination with low EA puts female athletes at an increased risk of developing conditions of the Triad, and further increases a female athlete's risk of experiencing stress fractures. Stress fractures present grave risk to the female athlete's sport participation and personal athletic performance and those who experience stress fractures during adolescence are considered at higher risk of developing post-menopausal osteoporosis (ISCD Writing Group, 2004). Efforts to prevent Triad conditions may result in avoidance of stress fractures.

Female Athlete Triad Screening and Return to Play

Early identification of Triad symptoms is essential in the prevention of the serious health consequences that may result from the onset of MI and low BMD. Few schools employ a Triad screening protocol (De La Torre & Snell, 2005), leaving adolescent athletes at risk of developing Triad conditions, undetected. According to De La Torre and Snell (2005), 33.0% of high schools report having Triad education available to female athletes, though only 9.0% of these programs require athlete attendance. High school athletic programs are currently failing to educate athletes about the Triad or identify Triad conditions among their athletes, making a Triad screening tool essential during the pre-participation physical exam (PPE). Annual PPEs provide a perfect opportunity to screen female athletes for the Triad at the high school level. Prior to sport participation, it's recommended athletes be asked questions regarding their age of menarche, frequency and regularity of current menstruation, and any changes in menstruation while participating in sports (Beals, 2002). Eating behaviors may be screened via the use of a nutrition and body weight history, as well as questions regarding food intake, any forbidden foods, weight satisfaction, and weight control measures (Beals, 2002). Risk factors to address during the PPE include history of MI and amenorrhea, history of stress fractures, history of depression, history of dieting/weight cycling, and presence of personality traits such as perfectionism or obsessiveness (De Souza et al., 2014). In addition, physical signs specific to Triad risk such as low BMI, weight loss, and orthostatic hypotension should prompt further investigation

(De Souza et al., 2014). A standard screening tool consisting of nine Triad-related questions has been created (De Souza et al., 2014). The Triad Consensus Panel recommends female athletes at the high school level undergo annual screening with the Triad-specific self-report questionnaire, followed by a more in-depth evaluation of whether the athlete has or is at risk for any of the Triad conditions (De Souza et al., 2014). Detection of any one Triad condition should prompt a thorough investigation for the remaining conditions (De Souza et al., 2014).

In the case of the detection of one or more Triad conditions during the PPE, a standard protocol is recommended in determining athlete clearance and return to play. Because there are currently no standardized Triad screening guidelines in place for athletic programs to adhere to, adolescent female athletes with the Triad are being cleared at their PPE without being properly assessed or treated, and often return to play without a structured follow-up procedure (De Souza et al., 2014). In order to prevent outcomes of low BMD including stress fractures (Barrack et al., 2014), a clearance and return to play procedure is needed to streamline efforts made by coaches and trainers to identify and further treat Triad conditions. This procedure may imitate the NCAA Concussion Management Program and return to play guidelines (NCAA Sports Science Institute, 2018). The NCAA Sport Science Institute has developed best practices for athletic departments to use in implementing a Concussion Management Program on their campuses (NCAA Sports Science Institute, 2018). An upcoming version of a Triad management program may mimic some aspects of the NCAA Concussion Management Program. For instance, the two main priorities of the Concussion Management Program are 1) education and 2) pre-participation assessment (NCAA Sports Science Institute, 2018). The second priority of the NCAA, and a main priority in Triad prevention, is the PPE. With a standardized procedure in place, female athletes experiencing the Triad will be flagged during the PPE and will receive the proper treatment to address their symptoms. If and when female athletes are diagnosed with the Triad, a protocol is needed to address athlete return to play. A stepwise progression of activity, such as the one outlined by the NCAA (2018), provides a guide for return to play guidelines following Triad diagnosis. The sequence by which female athletes increase their sport activity will most-likely depend on their specific symptoms and ensuing severity, though no matter how unique of a case, athlete progress needs observation and appropriate follow-up. According to the NCAA (2018), if at any point the student-athlete becomes symptomatic (i.e., more symptomatic than baseline) it is recommended the coach and/or trainer be notified and the student-athlete be returned to the previous level of activity. With protocols and procedures in place, schools and coaches are more well prepared and adolescent female athletes are at decreased risk of developing Triad conditions.

The main priority of the NCAA is providing education to prevent injury (NCAA Sports Science Institute, 2018). The NCAA recommends schools provide concussion fact sheets or other applicable educational material annually to student-athletes, coaches, team physicians, athletic trainers and athletics directors (NCAA Sports Science Institute, 2018). The same education is recommended for the Triad, as there is much information available; the required education material could include the Triad education video utilized by this study, or something very similar. Required education on athlete health has potential to provide a strong initiative in preventing health consequences of the Triad. It is recommended that education on the Triad and other health concerns regarding sport participation extend beyond female athletes and their coaches, to the parents of the players. Just as PPE are required for the athletes, a mandatory pre-season meeting may be implemented for each sports team's parent populace. At this meeting, education on athlete health could be presented to a captive audience and educational materials could be dispersed among families, so that everyone is on the same page in caring for the adolescent female athletes' health and safety. Topics of conversation could range from sleep schedules to academics, with the topic of the Triad on the frontlines.

Triad Education is Warranted

Alone or in combination, each condition of the Triad has potential to result in serious health consequences. Though prevalence of low EA, MI and low BMD are high among female high school athletes, knowledge of the Triad is minimal among this population (Day, Wengreen, Heath, & Brown, 2015; Feldmann, Belsha, Eissa, & Middleman, 2011). Brown et al. (2014) conducted a study with 170 female high school athletes (14-18 years) to determine knowledge of the Triad and its health implications among this population. Eight questions were used to assess Triad knowledge, including three questions regarding EA. Of the 170 athletes, only nine had heard of the Triad, and zero could correctly list the three Triad components. Few Triad questions were answered correctly, with a mean score of 2.97 ± 1.61 out of a possible score of 8 points. Forty-nine athletes thought that skipping a period during sports performance was normal, and only half of the participants (n = 83) knew that not eating enough could cause them to skip their period (see Table 2.5).

Feldmann et al. (2011) utilized a cross-sectional survey to determine knowledge of the association between MI and bone health among 103 female high school track athletes. Fewer than 10.0% of athletes knew that MI could impact their bone health and increase their risk for fracture, and 50.0% believed it was normal to skip their period. The median summative knowledge score among participants was 1 correct answer out of a possible 6, and lower knowledge scores were associated with self-reported MI (see Table 2.5).

Collegiate female athletes' knowledge of the Triad was assessed in a study by Day, Wengreen, Heath, and Brown (2015), and similar to studies conducted with high school athletes, low knowledge was reported among this population. A total of 25 female collegiate runners (19.5 ± 1.8 years) were were administered a questionnaire including ten questions used to assess Triad knowledge. Ten of the twenty-five athletes (40.0%) had never heard of the Triad, and though six participants (24.0%) could correctly name at least two components, only two (8.0%) could name all three Triad conditions. The most commonly missed question among the runners was "Each athlete has a set body fat percentage they should aim for to maximize their athletic performance", to which the correct answer is false; only 16.0% of participants answered this question correctly (see Table 2.5).

Because many female athletes are at risk of developing conditions of the Triad, it is imperative that all are educated on the disorder beginning at the high school level. (Thein-Nissenbaum & Carr, 2011a). Without knowledge of the Triad, it may be too late to prevent risk factors of the Triad before the athlete continues on to playing collegiate athletics.

Table 2.5: Studies Assessing Triad Knowledge among Female Athletes

Author (s)	Population (*N*)	Assessment Description	Results
Feldmann, Belsha, Eissa, & Middleman (2011)	High school female athletes (*N* = 103)	Questionnaire assessing knowledge and attitudes toward MI and its link to BMD	- Median summative knowledge score was 1 out of 6 - Lower knowledge scores were associated with MI (p = 0.035)
Brown, Wengreen, & Beals (2014)	High school female athletes (*N* = 170) and their coaches (*N* = 10)	Athlete Triad knowledge questionnaire Coach questionnaire addressing Triad knowledge, athlete observations, and team practices	- 9 athletes had heard of the Triad - 0 athletes could list the Triad components - Low athlete Triad knowledge (2.97 ± 1.61 out of 8) - 1 coach could identify Triad components - 4 out of 10 coaches reported an absence of team nutrition education

Triad Education Interventions

In order to prevent the severe health consequences of the Triad, female high school athletes are in need of education regarding adequate nutrition for their activity levels, as well as education on the detrimental effects of not consuming enough calories while participating in athletics. Previous studies report improvements in Triad knowledge and perceived susceptibility to the Triad following educational interventions (Brown, Wengreen, Beals, & Heath, 2016; Day, Wengreen, Heath, & Brown, 2015; Doyle-Lucas & Davy, 2011).

A significant increase in Triad knowledge was observed among female high school track athletes (*N* = 29, 14-18 years) after taking part in a peer-led nutrition education intervention implemented by Brown et al. (2016). The intervention itself included four peer-lead educational sessions, two of which included video clips used to stimulate discussion and reinforce main concepts. Six of the athletes' peers were chosen to lead the education sessions, and were initially trained on the content by a research assistant. Following the intervention, athlete Triad awareness and knowledge increased significantly (Pre: 4.72 ± 2.6; Post:7.68 ± 1.79; $p < 0.0001$). On average, participants attended three out of the four interventions; those who attended three or four sessions had higher Triad knowledge scores than those who attended one or two sessions (6.4 ± 2.14, 8.0 ± 1.50, respectively; $p = 0.03$). Poor retention of participants was reported a limitation of the study.

An increase in perceived susceptibility to the Triad was reported among pre-professional dancers (13-18 years) following an educational intervention by Doyle-Lucas and Davy (2011). The intervention was presented in the form of a DVD lecture series over a span of three 30-minutes class sessions. Dancers were randomized into an intervention group ($n = 231$) and a control group ($n = 90$) at the start of the study; the intervention group participated in the nutrition education program, while the control participants did not. Two questions were used to determine perceived susceptibility to the Triad both before and after the educational intervention: 1) "I believe that the Triad is a sever health problem affecting dancers," and 2) "If I had the Triad my dancing would suffer." Total Triad perceived severity scores among intervention participants showed great improvement (Pre: 7.7 ± 0.1; Post: 8.7 ± 0.1; $p \leq 0.05$) compared to the scores of the control participants (Pre: 7.6 ± 0.2; Post: 7.7 ± 0.2; $p \leq 0.05$). Group differences in results suggest the educational intervention was effective in increasing perceived severity to the Triad among adolescent dancers.

Increases in Triad knowledge among female collegiate track athletes ($N = 25$) were reported by Day, Wengreen, Heath, and Brown (2015) after implementation of a nutrition education intervention. Athletes (19.5 ± 1.8 years) were invited to attend six interactive sessions focusing on aspects of the Triad, led by either an undergraduate dietetics student or a Registered Dietitian Nutritionist (RDN). All participants were asked to complete a self-report questionnaire before and after the educational intervention; ten questions were used to assess change in Triad knowledge from pre- to post-intervention. The number of participants who could correctly name two or more components of the Triad increased from 24.0– 52.0% after the education intervention. Response to the Triad question, "Skipping my period is my body's way of saying that I'm training too hard," significantly changed from pre- to post-intervention, increasing from 40.7% of participants answering it correctly initially to 62.5% answering it correctly after the intervention ($p = 0.016$). Changes in the remaining nine questions were not regarded as significant; researchers attributed this finding to the fact that all athletes did not attend all six educational sessions (see Table 2.6).

Table 2.6: Triad Nutrition Education Interventions

Author (s)	Population (*N*)	Intervention Description	Results
Doyle-Lucas & Davy (2011)	Pre-professional adolescent ballet dancers (control, $n = 90$; intervention group, $n = 231$)	Three, 30-minute DVDs	↑ Perceived susceptibility to the Triad (7.7 ± 0.1 pre-intervention to 8.7 ± 0.1 post-intervention, $p \leq 0.05$)
Day, Wengreen, Heath, & Brown (2015)	Collegiate female athletes ($N = 25$)	Six, 30-minute nutrition education sessions led by a RDN or dietetic undergraduate student	↑ Triad knowledge ↑ Ability to name two or more Triad components (24.0% to 52.0%)
Brown, Wengreen, Beals, & Heath (2016)	High school female athletes ($N = 29$)	Four peer-lead educational sessions; video clips were used in sessions 2 and 4	↑ Triad knowledge (4.72 ± 2.6 to 7.68 ± 1.79, $p < 0.0001$)

Conclusions

The Triad is a disorder made up of the three interrelated conditions: low EA with or without DE, MI, and low BMD (Nattiv et al., 2007). The relationships among these conditions are due to low EA increasing a female athlete's risk of experiencing menstrual dysfunction, which leads to low estrogen production and the initiation of bone loss (Nattiv et al., 2007). Alone or in combination, each of these conditions pose serious risk to the health of the female athlete (Nattiv et al., 2007; Thein-Nissenbaum, 2013). Prevalence of Triad conditions among female high school athletes is significant (Barrack et al., 2008; Barrack et al., 2014; Beals, 2002; Brown et al., 2014; Hoch et al., 2009; Martinsen & Sundgot-Borgen, 2013; Nichols et al., 2006; Nichols et al., 2007; Pernick et al., 2006; Rauh et al., 2010; Thein-Nissenbaum & Carr, 2011a; Thein-Nissenbaum et al., 2011b), though knowledge of the disorder is low among this population (Brown et al., 2016; Feldmann et al., 2011). The negative health consequences resulting from the Triad underscore the critical need for prevention (Nattiv et al., 2007).

Previously implemented nutrition education interventions have shown to be successful in increasing Triad knowledge and perceived susceptibility to the Triad (Brown et al., 2016; Day et al., 2015; Doyle-Lucas & Davy, 2011), though limitations such as small athlete sample sizes, unrepresented sport types, lack of use of a control group, and athletes not attending all educational sessions have been determined as limitations. Further research is needed to address these limitations and to expand upon the limited research exploring the impact of Triad education directed at female high school athletes.

Chapter Three

Changes in Knowledge of the Female Athlete Triad Among Female High School Athletes Following a Brief Nutrition Education Intervention

Introduction

In the state of Idaho, female participation in high school athletics is on the rise. In 1974, just two years after Title IX was introduced, the number of females participating in high school athletics in the state Idaho was recorded at 4,123 across three different sports (basketball, volleyball, and track and field) (National Federation of State High School Associations, 2017). Today there are well over 20,000 adolescent females playing more than ten different sports across Idaho, including volleyball, basketball, softball, soccer, track and field, cross country, competitive cheer, dance, tennis, golf, and wrestling (IHSAA, 2017).

Within the panhandle of Idaho there are a cluster of high schools that compete in sports amongst themselves at different levels classified from division 1A (between 100-159 students) to division 5A (over 1,280 students) (IHSAA, 2017). Four of these schools include Lewiston (5A), Moscow (4A), Genesee (1A), and Troy (1A) high schools. Athletics are very popular among female high school students in this region, and the majority of them participate in one or more school-sanctioned sports. At Lewiston High School there were 1,048 students accounted for in the 2016-17 school year, 529 of which were female. Of the 529 female students, at least 245 of them (46.0%) competed in one or more sports. Moscow High School had 780 students overall in 2016, 368 of which were girls, and 140 out of the 368 (38.0%) played one or more sports. Sport participation is greater in the smaller school systems as there is less competition and often no try-outs. Troy High School had 86 high school students and of the 44 who were female, 68.0% (*n* = 30) of which played one or more sports. At Genesee High School there were 106 students in 2016, and 55 of them were females. With the highest participation rate of the four schools, 48 out of the 55 (87.0%) female students participated in at least on school-sanctioned sport at Genesee High School during the 2016-17 school year.

Due to the countless benefits provided by interscholastic athletics (Eime, Young, Harvey, Charity, & Payne, 2013; Warburton & Bredin, 2006; Women's Sports Foundation, 2009), participation in high school sports is encouraged among adolescent females. The benefits far outweigh the risks, though increases in sport participation also result in the rise of sports-related injuries (Matzkin, Curry, & Whitlock, 2015). One disorder female athletes experience frequently is the Female Athlete Triad (Triad). The Triad is a disorder comprised of three interrelated conditions: low energy availability (EA), menstrual irregularity (MI) and low bone mineral density (BMD) (Nattiv et al., 2007). The definition of EA is the amount of dietary energy remaining for usual body function after accounting for energy lost during exercise training (Nattiv et al., 2007). In order to achieve optimal EA, athletes need to consume a minimum of 45 calories per kilogram of fat free mass (FFM) (Hoch et al., 2009; Nattiv et al., 2007). Consuming too little dietary energy to sustain increased physical activity demands, as well as normal day-to-day activities, may result in the onset of low EA. One consequence of low EA is MI, or the disruption of normal menstrual function due to the suppression of reproductive hormones, including estrogen (Nattiv et al., 2007). Because of the key role estrogen plays in calcium absorption and bone mineralization (Greydanus & Patel, 2002; Manore, 1999), the absence of normal estrogen levels may cause young female athletes to develop low BMD (Manore, 1999; Nattiv et al., 2007).

Premenopausal females participating in sports at all levels are at risk of developing conditions of the Triad, though the current literature indicates significant prevalence of this disorder among female high school athletes (Hoch et al., 2009; Nichols, Rauh, Lawson, Ji, & Barkai, 2006; Thein-Nissenbaum & Carr, 2011a; Thein-Nissenbaum et al., 2011b). As many as 54.0% of high school athletes present with at least one condition of the Triad (Hoch et al., 2009; Nichols et al. 2006), and another 4.0 – 18.0% have a combination of any two conditions (Hoch et al., 2009; Nichols et al., 2006; Nichols et al., 2007; Thein-Nissenbaum et al., 2011a; Thein-Nissenbaum et al., 2011b). Between 1.0 – 1.2% of female high school athletes are experiencing all three conditions of the Triad, simultaneously (Hoch et al., 2009; Nichols et al., 2006). Despite the high prevalence of Triad conditions among female high school athletes, knowledge of the disorder is significantly low (Brown, Wengreen, & Beals, 2014; Feldmann, Belsha, Eissa, & Middleman, 2011). Fortunately, nutrition education interventions have shown successful in improving Triad knowledge and perceived susceptibility to the Triad among female athletes (Brown, Wengreen, Beals, & Heath, 2016; Day, Wengreen, Heath, & Brown, 2015, Doyle-Lucas & Davy, 2011).

The purpose of the present study was to assess changes in Triad knowledge among female high school athletes following participation in a brief Triad educational intervention. It was hypothesized that Triad knowledge scores would show greater improvement among a group of female high school athletes after participation in a brief Triad education intervention in comparison to Triad knowledge scores observed among a control group.

Methods

This study was conducted between October 2016 and February 2017 at four North Idaho high schools. All participants attended a single, hour-long session led by researchers at their respective school. Pre- and post-intervention questionnaires were used to assess changes in Triad knowledge following a brief educational video intervention. The University of Idaho Institutional Review Board approved this study (see Appendix A).

Participant Sample. Female athletes (*N* = 93, 15.89 ± 1.2 years) attending one of four high schools in North Idaho (Lewiston, Moscow, Genesee, and Troy high schools) consented to participate in the study. Participants included female athletes who played at least one school-sanctioned sport including golf, soccer, tennis, volleyball, basketball, softball, track & field, cross-country, and/or cheerleading/dance.

Data Collection. Initial contact with each of the schools was made by contacting the respective athletic directors of Lewiston, Moscow, Genesee and Troy high schools. Each athletic director provided contact information of the coaches involved in fall or winter sports. There was variation in sport representation from school to school, but the common consensus made was that the larger teams of fall and winter sports (basketball, cheerleading, volleyball) would heed the greatest response rate compared to some of the smaller teams (tennis, soccer, golf, softball). The sports teams represented in this study were a convenience sample made up of the school-sanctioned sports that were in season at the time of the study, and whose coaches were both responsive to our invitation, and supportive of their athletes' participation in the study. With approval of participating coaching staff, researchers set up a date and a time to visit each school according to practice and competition schedules. Each school was visited only once in order to prevent the spread of Triad information among athletes who had not yet received the intervention.

Participation in this study was voluntary. Parental consent and child assent were obtained prior to beginning research. Participants who were 18 years old at the time of the study did not need to provide parental consent. Athletes who did not return the consent/assent form were permitted to participate in educational intervention and control activity; however, no data was collected from them. A drawing for a $25.00 Amazon gift card was used as an incentive at each school to increase athlete participation.

Intervention Design. An education intervention was held at each of the four respective high schools. Each school provided a classroom with a projector and screen to facilitate viewing of the video, as well as an additional classroom, gym, or open space for the control group activities to take place.

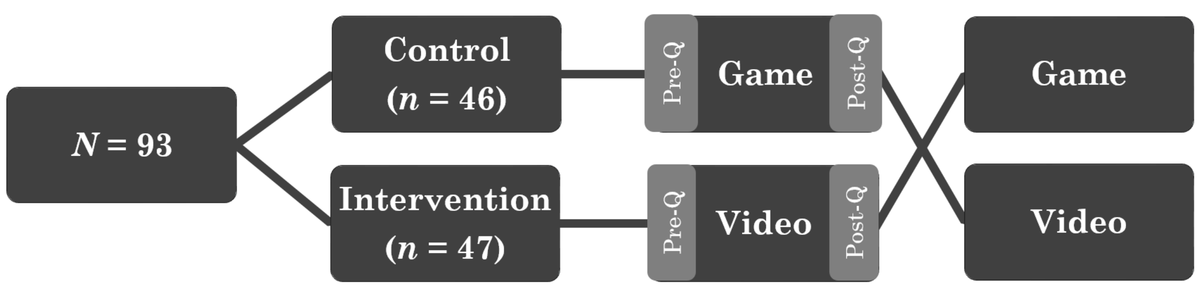
Both the pre-intervention and post-intervention questionnaires were distributed to athlete participants at the same time. Athletes were instructed to complete and hand-in the pre-questionnaire, while leaving the post-questionnaire face-down on their desk. Once the pre-questionnaires were collected from all participants, the intervention group took part in a ten-minute Triad education session, while the control group spent the same ten minutes playing a food-related game involving no information related to the Triad.

During the education session, athletes belonging to the intervention group viewed a ten-minute educational video produced by Brown (2015) providing Triad-related nutritional information pertaining to female athletes. The video included footage of a Registered Dietitian Nutritionist (RDN) defining Triad etiology and progression, testimonies from former collegiate athletes who experienced the Triad, as well as discussion by a RDN on the importance of nutrition in preventing the onset of Triad risk factors.

While the intervention group watched the video, the control group participated in a food-related game in separate location. This game involved no information on the Triad. The game chosen by researchers involved taping a notecard with the name of a food written on it to the back of each of the athletes' shirts without their knowing what food they were assigned. Each athlete was to search for their "partner" according to the food assigned to them only by asking the other players questions such as "Am I a breakfast food?". Once each athlete found their counterpart (e.g. salt and pepper, mashed potatoes and gravy, PB and jelly, etc.), they were asked to sit quietly until the other group finished their activity.

Once the video came to an end and the control group game was finished, all participants were instructed to flip over and complete their post-questionnaire and return it to one of the researchers. With all questionnaires collected, the two groups of participants then switched rooms in order to take part in the opposite activity. The control group was then able to watch the video containing the Triad information, while the intervention group played the food game. Each of the sessions took an average of 60 minutes. Questionnaires were not collected during the second session (see Figure 3.1).

Figure 3.1: Sequence of Intervention



Research Instruments. All participants completed a brief pre-intervention questionnaire that gathered anthropometric and demographic information (age, height, weight, sport/s, etc.), evaluated the potential presence and severity of Triad risk factors (menstrual history, eating attitudes, and weight control measures), and assessed knowledge of the Triad. Each questionnaire was assigned a number; participants were randomly assigned a number when questionnaires were administered.

The pre-questionnaire contained twelve questions from the Low Energy Availability in Female Athletes Questionnaire (LEAF-Q) (Melin et al., 2014) and the entire Eating Attitudes Test 26 (EAT-26) (Garner, Olmsted, Bohr & Garfinkel, 1982). The LEAF-Q is a brief questionnaire aimed to identify individuals at risk of the Triad by assessing self-reported physiological symptoms linked to persistent energy deficiency, with or without disordered eating (Melin et al., 2014). The EAT-26 is a widely used standardized measure of symptoms and concerns characteristic of eating disorders (ED). The EAT-26 Test is made up of 26 close-ended questions in which athletes can choose from six answers ranging from "Always" to "Never." This test cannot diagnose an ED, though those who score above 20, report using pathogenic weight control behaviors, or have lost ≥ 20 pounds in the previous month should be referred to a qualified professional to determine if they meet the diagnostic criteria of an ED (Garner et al., 1982).

The chosen Triad knowledge questions on the pre- and post-questionnaires included adaptations of those used by Feldmann et al. (2011), EA-related questions used by Brown et al. (2014), and three additional questions used to specifically address concepts discussed in the educational video (see Appendix B & C). The Triad knowledge questions were evaluated for content validity, and have been found to be reliable (unpublished data).

Procedure for administering research instruments. At the beginning of each session, researchers thoroughly explained to all participants that they did not have to complete the questionnaire if they did not want to, and that if any questions made them uncomfortable they did not have to answer those questions. Based on comprehension issues during previous use of this questionnaire, researchers were sure to explain that "oral contraceptives" were referring to birth control, and that the section of the EAT-26 regarding "exercising more than 60 minutes a day" was solely referring to exercise aimed at losing weight, not exercise related to sport participation (see Appendix B). It was also clarified that the athlete's answers to the survey questions would be kept completely anonymous and would only be seen by the researchers in order to evaluate the study's results.

Data Analysis. Participant responses to close-ended categorical questions regarding age, height, weight, and main sport were summarized by calculating means, standard deviations, frequencies, and percentages. In accordance with the CDC growth charts (Kuczmarski et al., 2000), body mass index (BMI) for age was calculated for each participant using their self-reported height, weight, and age. Triad knowledge scores were calculated by summing correct answers from the pre- and post-intervention surveys. Correct responses to Triad knowledge questions received one point, while unanswered or incorrectly answered questions received a score of zero; each participant received a score out of ten.

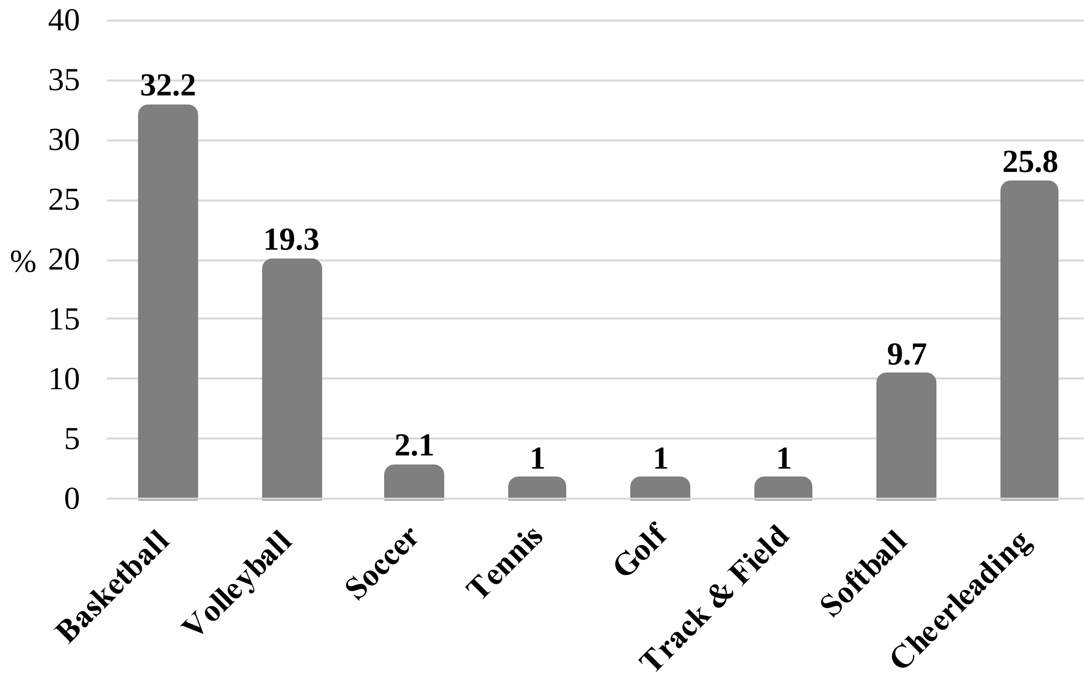
In testing for normality using the Shapiro-Wilk Test, the calculated difference in knowledge scores for both the control and intervention groups was determined to be not normally distributed ($p > 0.05$), therefore non-parametric tests were used to analyze all data.

Mann-Whitney U tests were conducted to compare mean ranks of knowledge scores between the control and the intervention groups from pre- to post-intervention. The Wilcoxon signed-rank test was used to compare pre- and post-intervention responses to each Triad knowledge question. A significance level of $p < 0.05$ was set for all statistical tests. All data was analyzed using SPSS (Statistical Package for the Social Sciences, Version 23).

Results

Participant Characteristics. Ninety-three female athletes (15.89 ± 1.2 years) consented to participate and were administered questionnaires during the study. Out of the 245 athletes at Lewiston High School, 29 took part in the study (12.0% response rate). Fourteen out of 140 female student athletes from Moscow High School participated (10.0% response rate). And from Troy High School and Genesee High School, 36.7% and 81.2% of athletes participated in the study (11/30 and 39/48 athletes, respectively). Forty-seven participants were randomly assigned to the intervention group and the other 46 to the control group. Information regarding demographics and potential risk of developing Triad risk factors were assessed among all participants, though change in Triad knowledge was only evaluated among 90 participants (control = 44, intervention = 46) due to three athletes leaving one or more questions blank on the Triad knowledge portion of the questionnaire. Over half of the participants indicated their main sport to be basketball (n = 30) or cheerleading (n = 24), with the other sports including volleyball, softball, soccer, golf, tennis, and track (see Figure 3.2).

Figure 3.2 Percent of Participants Representing Each Sport



Calculated BMI for age percentiles from participant reported height, weight, and age indicated that 84.7% were within the normal range (5th – 85th %ile), 14.1% were overweight (≥ 85^{th} %ile), and 1.1% were considered obese (≥ 95^{th} %ile) by the BMI for age percentile distribution. Forty-two athletes (45.1%) indicated that they wanted to lose weight and of those who wanted to lose weight, 25 athletes (59.5%) were within normal BMI range. All 93 athletes received a score on the EAT-26 questionnaire; five of the athletes (5.3%) scored above the cutoff score of 20, with a high score of 40 (see Table 3.1).

Table 3.1 Athlete Baseline Characteristics

Participants (N = 93)	n (%) / Mean ± SD
Age, yrs	15.79 ± 1.2
Height, in	63.36 ± 2.71
Weight, lbs	135.01 ± 18.58
BMI, kg/m²	22.22 ± 2.78
Underweight (< 5th %ile)	0 (0.0%)
Normal weight (5th – 85th %ile)	78 (84.7%)
Overweight (≥ 85th %ile)	13 (14.1%)
Obese (≥ 95th %ile)	1 (1.1%)
Wanted to gain weight	4 (4.3%)
Wanted to lose weight	42 (45.1%)
Wanted to lose > 10 pounds and were within a healthy weight range	25 (59.5%)
Average desired weight change	-10.64 ± 7.44
Triad knowledge score (out of 10)	3.88 ± 1.95

LEAF-Q Results. The LEAF-Q portion of the questionnaire included twelve questions (see Appendix B) and was completed by all 93 participants. Thirty-seven of the participants (39.8%) indicated that they had been absent from training or competition in the last year due to injuries, the majority of which were absent for 1-7 days (n = 21, 56.8%). Participants were asked to describe their injuries; reported injuries included sprained ankles, broken wrists, concussions, and general pain, with the injuries of most concern regarding the Triad being reports of "really bad" shin splints (n = 1) and a foot fracture (n = 1).

Of the 93 participants, 84 indicated that they could accurately answer questions regarding their period (see Table 3.2), thus only those 84 participants' responses were considered in assessing menstrual status among the athlete sample. Participants were asked to disclose the age they had their first period (see Appendix B); 68 athletes reported a normal age of menarche (younger than 15 years), though two others reported an age of menarche older than 15 years of age, indicating the presence of primary amenorrhea. Two athletes reported that they were currently experiencing an absence of menstruation for three or more consecutive months, indicating secondary amenorrhea, and another two reported that this had been the case for them in the past (see Table 3.2). No correlation was found between the incidence of primary or secondary amenorrhea and participants' eating attitudes and behaviors.

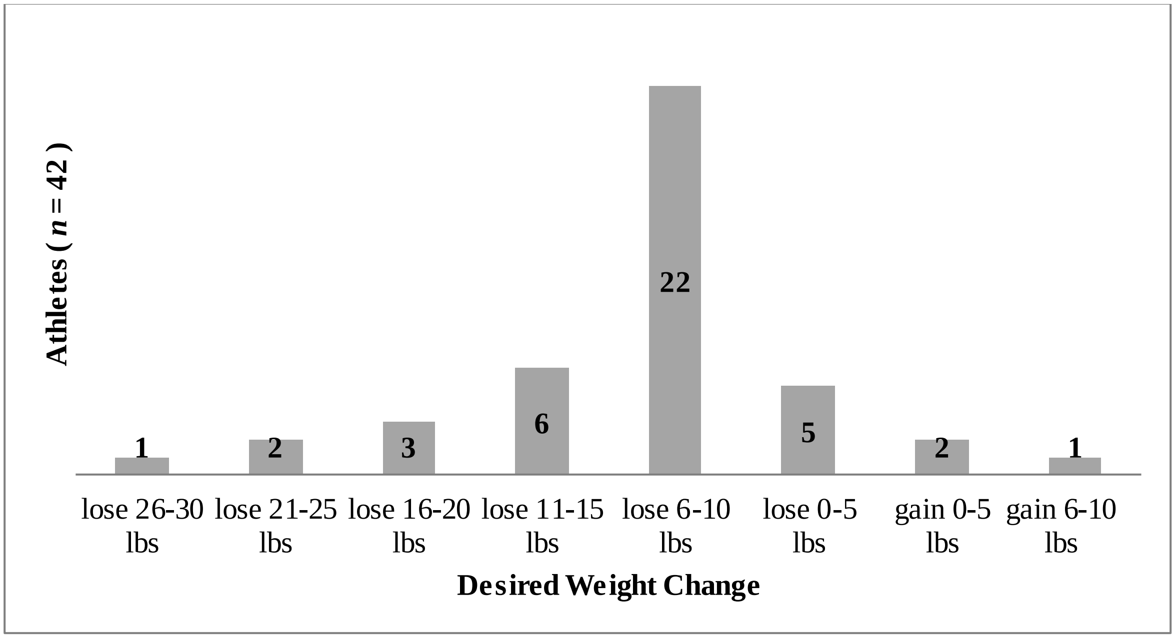
Table 3.2 Low Energy Availability in Females Questionnaire Results

Participants (N = 93)	n (%) / Mean ± SD
Accuracy of reporting menstrual status indicated by participants	
Very accurately	21 (22.6%)
Fairly accurately	63 (67.7%)
Not very accurately	9 (9.7%)
Age at menarche [a]	12.34 ± 1.27
≤ 11 years	17 (20.2%)
12 – 14 years	60 (71.4%)
≥ 15 years	2 (2.4%)
Menstrual irregularity	
Primary amenorrhea[a]	2 (2.4%)
Current secondary amenorrhea[b]	2 (2.4%)
History of secondary amenorrhea[c]	20 (23.8%)

[a] Only the 84 athletes who reported the ability to accurately report on their menstrual status were included from this point forward
[b] Primary amenorrhea is the failure to menstruate by age 15
[c] Secondary amenorrhea us the absence of menstruation for a minimum of three consecutive months

Eighty-nine participants answered the question regarding how often they eat during their training/competition season, with responses ranging from zero to ten hours between meals (2.84 ± 2.26 hours). Four participants (4.3%) reported currently trying to gain weight and 42 out of 93 participants (45.2%) indicated currently trying to lose weight. Of the athletes that indicated that they were trying to lose weight, 39 reported the amount of weight they were trying to lose; proposed weight loss ranged from 3 to 30 pounds, with twelve athletes reporting that they wanted to lose at least 15 pounds (see Figure 3.3).

Figure 3.3 Proposed Change in Weight Reported by Athletes



EAT-26 Results. Scoring greater than 20 on the EAT-26 is indication of high risk for DE among athletes. Of the 93 participants, five (5.4%) scored above 20 on the EAT-26 Test with the highest score being 40 points (see Figure 3.4). No correlation was found between participants' initial Triad knowledge and their risk for DE.

Table 3.3 Eating Attitudes Test-26 Results

Participants (N = 93)	n (%) / Mean ± SD
Risk for DE [a]	14 (15.1%)
Gone on eating binges	3 (3.3%)
Made themselves sick (vomited)	2 (2.2%)
Used laxatives, diet pills, diuretics	2 (2.2%)
Exercised more than 60 minutes per day	7 (7.5%)
Lost 20 lbs or more in the last month	0 (0.0%)
EAT-26 score	6.3 ± 7.0

[a] EAT-26 scores >20, report of pathogenic weight control behaviors, or loss of ≥ 20 pounds in the last month

In response to EAT-26 questions, 29 participants (31.2%) reported that they are usually to always terrified of being overweight, and 52.0% reported finding themselves preoccupied with food at least sometimes. For further summary of participant responses to EAT-26 questions see Figure 3.4. The final five questions at the end of the EAT-26 ask participants to report how often they have engaged in pathological weight control behaviors (see Appendix B). Fourteen (15.1%) participants reported that they engage in at least one of the described behaviors often enough to classify them with a risk for DE (see Table 3.3).

Figure 3.4 Athlete Eating Attitudes Test-26 Scores

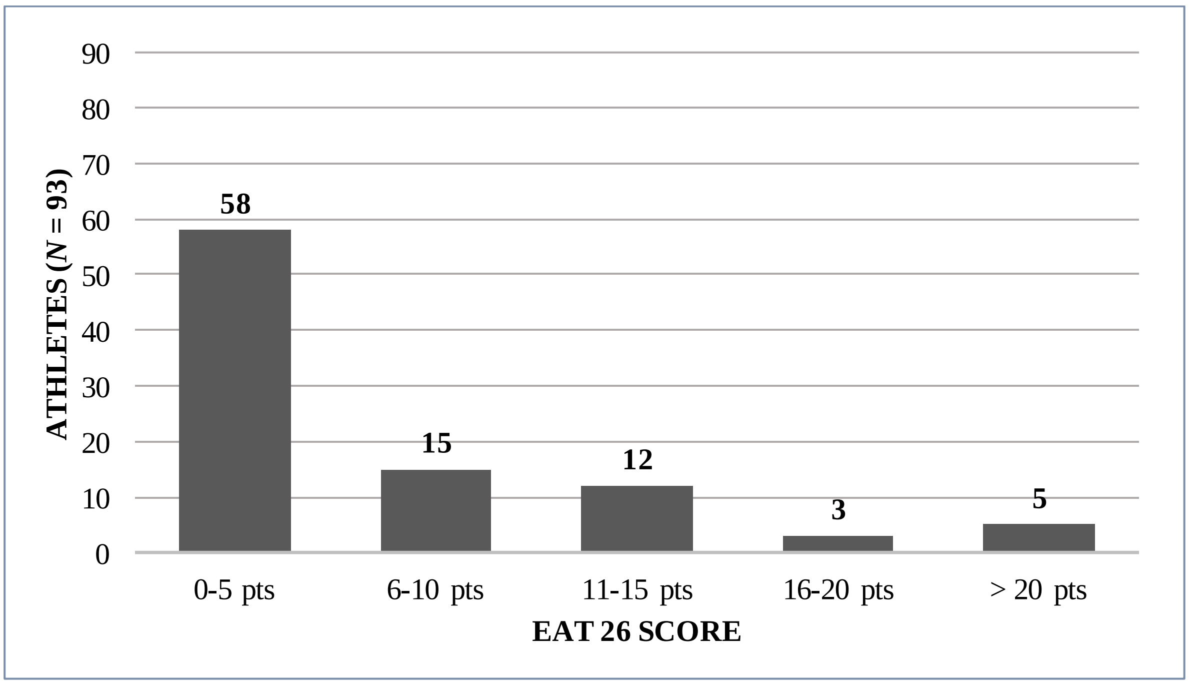
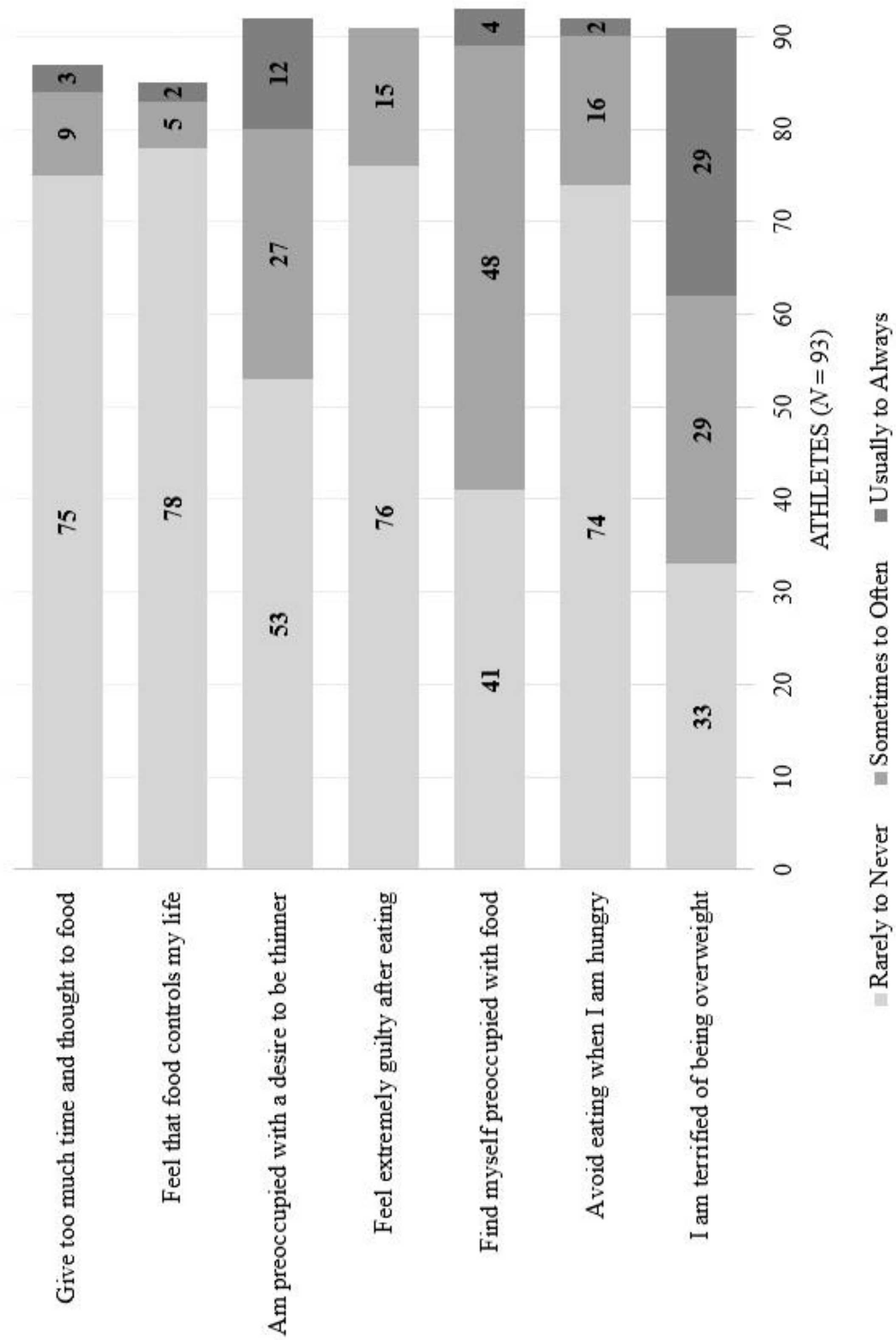


FIGURE 3.5 ATHLETE RESPONSES TO EAT-26 STATEMENTS

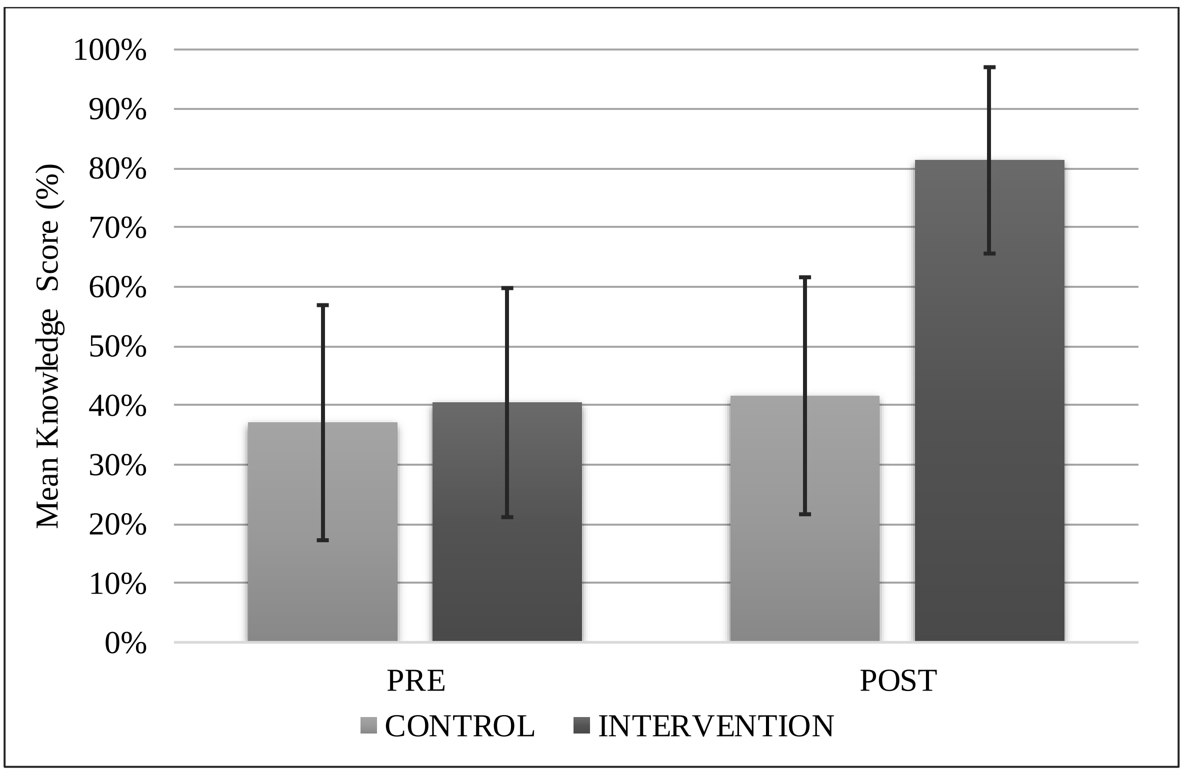


Triad Knowledge Results. The Triad knowledge portion of the pre-and post-intervention questionnaires was made up of eleven questions (see Appendixes B & C). Each of the questions were written in statement form, such as "Stress fracture risk is not influenced by the amount of calories I consume." Participants responded to each of the eleven statements using a Likert scale ranging from "Strongly Agree" to "Strongly Disagree," with "Don't Know" as an available answer. Each question had two responses regarded as correct, depending on the correct response to the respective question; "Strongly Agree" and "Agree" would both be considered correct on a question rendered a true statement, while "Strongly Disagree" and "Disagree" would both be correct for a statement rendered false on the questionnaire. The eleventh question, worded "I consume enough calories from my diet to support my health and physical activity" was not scored due to it not being a true assessment of knowledge, but rather a matter of the athlete's opinion regarding their calorie intake. Correct responses to the ten remaining questions received one point, while incorrect responses or questions answered "Don't Know" received zero points. Participants were given a score out of ten, other than in the case that any one or more questions were left unanswered, in which case that questionnaire became invalid and was left unscored. Triad knowledge scores were calculated for the pre- and the post-questionnaires, and change in knowledge was assessed by subtracting the pre-questionnaire score from the post-questionnaire score.

Change in Triad knowledge was only evaluated among 90 participants (control = 44, intervention = 46) due to three participants leaving one or more questions blank on the Triad knowledge portion of the questionnaire, invalidating their results. Results of Mann-Whitney U tests revealed that pre-questionnaire Triad knowledge scores between groups were similar

(Control: 42.91; Intervention: 47.98; $p = 0.350$), though post-questionnaire knowledge scores were significantly higher among the intervention group in comparison to the control group (Control: 25.58; Intervention: 64.55; U = 135.500; $p < 0.001$). In addition, participants in the intervention group achieved greater increases in Triad knowledge following the intervention, in comparison to the control (Control: 26.09; Intervention: 64.07; U = 158.00; $p < 0.001$). No correlation was found between participants' pre-intervention Triad knowledge score and their risk for DE, nor was there correlation with incidence of primary or secondary amenorrhea.

Figure 3.6 Mean Triad Knowledge Scores Before and After Educational Intervention



Questions answered "Don't Know" the most among all participants on the pre-questionnaire included "Female athletes who skip their period may have difficulty becoming pregnant" (48.3%), "Not eating enough calories could cause me to lose or skip my period"

(39.8%), “Stress fractures occur more often in girls that skip their period” (58.1%), and “Bone loss that occurs in my teens and early twenties is completely reversible” (41.9%).

Significant improvements in correct responses by the intervention group were seen among all Triad knowledge questions except for question nine (see Table 3.4). It was concluded that the Triad education video did not address the topic of body fat clearly enough so that athletes would be able to recognize the correct response on the post-questionnaire. Negative differences indicate a correct response to the question on the pre-questionnaire, and an incorrect response to the same question on the post-questionnaire. Ties indicate that the athlete(s) either marked the exact same answer on both the pre- and post-questionnaires, or they responded to the question correctly or incorrectly on both questionnaires, no matter their answer choice. Positive differences indicate the athletes who responded incorrectly on the pre-questionnaire, and then went on to answer the same question correctly on the post-questionnaire. The fact that all questions saw a majority of positive differences suggests that the athletes belonging to the intervention group increased their knowledge of the Triad following the nutrition education intervention (see Table 3.4).

Participant Feedback. At the end of the post-questionnaire (see Appendix C), all participants were provided the opportunity to give feedback about the presentation and the information provided to them. Of the 47 participants belonging to the intervention group, 13 (28%) provided commentary on the study. The words “helpful” and “beneficial” were widely used among intervention participants, and many stated that they intend to apply the information they learned to their own sport participation and future health (see Table 3.5).

Table 3.4: Wilcoxin Signed-Rank Test Results among Intervention Participants

Question	Differences		*p* – value
1. Skipping or losing my period while playing sports is normal. (F)	Negative Differences	1	<0.001
	Positive Differences	35	
	Ties	11	
2. A menstrual cycle typically occurs every 28 ± 7 days. (T)	Negative Differences	2	<0.001
	Positive Differences	17	
	Ties	28	
3. I'm not old enough to have weak bones that fracture easily. (F)	Negative Differences	7	0.006
	Positive Differences	25	
	Ties	15	
4. Female athletes who skip their period may have difficulty becoming pregnant. (T)	Negative Differences	1	<0.001
	Positive Differences	39	
	Ties	6	
5. Not eating enough calories could cause me to lose or skip my period. (T)	Negative Differences	1	<0.001
	Positive Differences	42	
	Ties	4	
6. Stress fracture risk is not influenced by the amount of calories I consume. (F)	Negative Differences	2	<0.001
	Positive Differences	35	
	Ties	10	
7. An athlete should eat every 2-3 hours during times of training and competition. (T)	Negative Differences	3	<0.001
	Positive Differences	25	
	Ties	19	
8. Stress fractures occur more often in girls that skip their period. (T)	Negative Differences	0	<0.001
	Positive Differences	38	
	Ties	9	
9. There is no set body fat percentage that is required for optimal athletic performance. (T)	Negative Differences	16	0.841
	Positive Differences	17	
	Ties	14	
10. Bone loss that occurs when I am in my teens and early twenties is completely reversible. (F)	Negative Differences	11	0.037
	Positive Differences	22	
	Ties	13	

Table 3.5: Participant Feedback

Category	Athlete Commentary
Overall enjoyment	"Interesting and relevant information! I thought it was a great video and study altogether." "This was really good. I'm glad I did it." "It was really good and nice to hear from someone closer to my age."
Knowledge gain	"I gained knowledge that I did not know before." "It really helped! Now I completely understand." "It was helpful information that I didn't know." "I think it was very helpful and gave me a lot of good information. It also explained a lot of things to me that will be very helpful." "I feel like this presentation was very beneficial to me. I realize now how important having a regular cycle and eating good meals is."
Advocate for future use	"I found this very useful and think most female athletes would find this beneficial." "I don't think a lot of female athletes know about this information, but I think it's important for us to know about these things." "I think that it was very useful and someone may be battling their own problem that they may not have wanted to say anything about." "I think it is really important for athletes to learn this information, and it's great that female athletes are being taught this information to prevent this from happening to them." "It was good information! More girls that play sports should look into this information."
Personal application	"I think it was really helpful for me to know this because I have gone without my period for that long. I know now that it's not healthy for that to happen and I am definitely going to eat enough so I don't have those problems again." "I feel like it will help me a lot in the future." "This was great and helpful information. It's good to know where I stand now as a female athlete and what I can do to better my current performance and future health. Thank you!"

Discussion

Athlete responses to pre-intervention questionnaires revealed that many of the 93 athlete participants were at risk of developing one or more conditions of the Triad at the time of the study. The LEAF-Q portion of the pre-questionnaire revealed prevalence estimates of primary and secondary amenorrhea among athlete participants similar to those determined in previous research (Barrack, Rauh, & Nichols, 2008; Brown et al., 2014; Brown et al., 2016; Nichols et al., 2006). Five athletes (5.4%) scored greater than 20 on the EAT-26, indicating existing subclinical DE behaviors proportionate to estimates reported by previous research (Barrack et al., 2014; Beals, 2002). Similar to Beals (2002), athletes belonging to this study reported DE behaviors, though no correlation was found between DE and prevalence of MI. Due to the low prevalence of injuries among athletes in this study, associations with DE and injuries could not be evaluated. This study did not scientifically measure bone density, therefore an estimate of low BMD among this participant sample is not available.

Similar to prior research (Brown et al., 2016; Feldmann et al., 2011), initial Triad knowledge among female athlete participants was low, though increases in Triad knowledge were reported after implementation of the nutrition education intervention (see Figure 3.6). Athlete responses on the pre-intervention questionnaire revealed similar Triad knowledge between groups, though following the intervention post-questionnaire scores were significantly higher among the intervention group compared to the control. Due to the use of a control group, these findings suggest that the intervention was successful in increasing Triad knowledge and that the changes observed were not due to chance. In using control group participants as a benchmark, the effectiveness of the intervention could be evaluated more thoroughly than in previous studies not utilizing a control group.

Nutrition education interventions intended for athletes must take into consideration the amount of time athletes are willing to spend outside of practice and competition to learn about nutrition. Many of the participants recruited for the studies by Brown et al. (2016) and Day et al. (2015) did not attend all sessions included in the education intervention. The nutrition education intervention in the present study required only ten minutes of athletes' time to watch a brief Triad education video, thus eliminating the challenge of persuading athletes to attend multiple sessions. Athletes in this study represented a variety of sports, in comparison to prior studies that focused in on specific athletes, such as runners or dancers. This study also employed a control group, an aspect that many studies fail to include.

The video intervention utilized in this study requires little time and provides accurate information introduced by RDNs and former female collegiate athletes. The video is available online, making it portable and easy to administer. It can be viewed on any computer or mobile device, and with access to a projector and accompanying tools, it may be projected on a big screen in front of a large group of athletes. In comparison to peer-lead Triad education interventions, which require small group interactions between athletes and educators, presenting an educational video allows coaches/trainers/health educators the opportunity to educate athletes on the Triad at a much larger ratio of athletes-to-presenter. Also more beneficial to the athlete is the fact that this video can be watched multiple times, allowing the athlete to better retain the information presented, or to come back to the video after some time has passed. This form of Triad education does not require presentation by a professional, or training of any kind, making this form of education entirely realistic for use in any athletic program, anywhere in the country. With its easy-accessibility, this video could be viewed during the initial pre-season assembly that many teams host prior to their first practice. Coaches could also make viewing this video a requirement prior to their participation in their chosen sport, whether the team were to watch the video individually, or in unison. Overall, having such a readily available form of Triad education leaves little reason for female athletes of all ages to not be educated on Triad risk and prevention.

There are nutritional considerations related to sport participation that were not considerably emphasized in the video, including the importance of consuming adequate amounts of micronutrients such as calcium and iron. Inadequate intake of calcium increases a female athlete's risk for elevated bone turnover (Barrack, Van Loan, Rauh, & Nichols, 2010) and stress fractures (Manore, 1999), therefore it is important that female athletes are encouraged to consume enough calcium-rich foods to keep their bones healthy. Calcium was mentioned in the video intervention, though the focus of the video was on low EA and MI. Low EA may lead to secondary amenorrhea (Nattiv et al., 2007). Barrack et al. (2010) reported greater risk for elevated bone turnover with secondary amenorrhea (odds ratio = 20.83) in comparison to inadequate calcium intake (odds ratio = 5.5). Iron consumption is also an important topic, as iron deficiency is one of the most prevalent nutritional deficiencies recognized among female athletes (Greydanus, Omar, & Pratt, 2010). Education on proper nutrition, including the consumption of foods containing iron (such as fortified cereals, fish, meat, and eggs) is essential in the prevention of iron deficiency anemia among female athletes (Greydanus et al., 2010). Because this study did not assess the athletes' dietary intake, it is not known whether any of the participants were taking one or more mineral supplements or multivitamins.

It is also important to consider male athletes' education in regard to the relationship between nutrition, athletics, and health. This is important to note, because parallels have been found between the Triad conditions and similar symptoms experienced by male athletes (Tenforde, Barrack, Nattiv, & Fredericson, 2016). Published evidence demonstrates that male athletes, especially those participating in sports emphasizing leanness, may experience symptoms and health consequences similar to those experienced by females diagnosed with the Triad (Tenforde et al., 2016). Similar to the Triad, male athletes may experience conditions of low EA with or without DE, reduced sex steroid hormones (testosterone), and impaired bone health (Tenforde et al., 2016). Because impending research has determined such similarities in the influence of low EA on impaired health among both sexes, a new term has been proposed to define this new health manifestation. The International Olympic Committee (IOC) deemed the term "Relative Energy Deficiency in Sport (RED-S)" (Mountjoy et al., 2014). Because this term is fairly new, there continues to be limitations to using this term (De Souza et al., 2014). Telforde et al. (2015) recommend continuing the use of the term 'Triad' until there is a stronger understanding of the mechanisms and outcomes of the symptoms occurring in active males that appear to parallel the Triad.

As prevalence of the Triad continues to rise, it is essential that efforts continue to be made in educating athletes, their coaches, and their parents. The education intervention implemented in this study was effective and well-liked. Many of the athlete participants stated that they found the video intervention beneficial and they recommend more athletes be educated on the same material. These results suggest that the video used in this study may be effective form of Triad education that should be considered for use in high school athletic programs to increase Triad knowledge among female athletes.

Limitations. All data was self-reported by athlete participants, thus only inferences can be made. This research study did not scientifically measure EA, menstrual function, or BMD; thus, these risk factors were only assessed by predictions made based on participants' responses to provided survey questions. In addition, change in behavior (calorie consumption, etc.) was also not assessed in this study.

A final limitation of the present study is that knowledge of the Triad was not assessed beyond the immediate post-intervention survey, thus this study can only conclude whether there was instantaneous knowledge gain post-intervention. The results of this study cannot infer that the athletes retained this knowledge following the post-intervention survey.

Implications for Future Research

The use of an informative video as a Triad education intervention was successful in improving Triad knowledge among female high school athletes. This form of Triad education may be utilized in future research endeavors. Because there are few published studies on the efficacy of Triad education interventions, there is an opportunity for future research to determine which form of education is best received by athletes at the high school level, and beyond. Information on the Triad can be delivered in a number of ways, whether it be by lecture, or via an informative flyer, video, or podcast. The modalities by which adolescents, especially are best receiving information is continuously transforming; therefore, the most effective way of administering education on the Triad and other health topics is also always shifting. Additional evidence is needed to pinpoint the most effective form of Triad education to be used in achieving the greatest comprehension among female athletes of all ages.

Another aspect of Triad education interventions that was not addressed in the present study is the potentially diversified change in knowledge among female athletes, dependent on who is presenting the Triad information. For instance, future studies could set out to determine whether female athletes better receive information regarding their eating behaviors and menstrual function from a male coach, or a female coach. Or, research could delve into whether it is most effective to have someone familiar to the athletes (coach, trainer, teacher, etc.) teach them about the Triad, in comparison to having someone new (RDN, female college athlete, sport physician, etc.) present the Triad education information. A female dietetics student from a local university presented the Triad education in this study, which was well-received by the high school athletes. One athlete participant left a comment that said, “It was really nice to hear from someone closer to my age,” which may also be taken into consideration in developing a new study to assess efficacy of a Triad education intervention.

The Triad education video used in the present intervention included footage of a RDN describing Triad etiology and progression, and another RDN discussing fueling strategies to reduce Triad risk. Nutrition plays a major role in preventing the negative consequences of the Triad, in addition to the importance of healthy eating in advancing the athlete’s career. Previous research has demonstrated that education provided by RDNs is well received by female athletes (Day et al., 2015), and because RDNs are the experts in food and nutrition, having a RDN discussing prevention solutions in the intervention is strongly recommended. Researchers are encouraged to use the video used in this intervention, as there are two RDNs represented within the video, each offering their professional advice in regard to prevention of the Triad.

The current study did not assess retention of Triad knowledge farther than immediately post-intervention. Future research in determining the effectiveness of different forms of Triad education should consider issuing a follow-up questionnaire, weeks to months after the intervention, in order to determine the level of retention of the information presented during the intervention. In addition, this educational intervention addressed only the first level of Bloom's Taxonomy. Benjamin Bloom's *Taxonomy of Educational Objectives* provides a framework for educators to apply to their teaching style (Armstrong, n.d.). This framework includes six major levels: Knowledge, Comprehension, Application, Analysis, Synthesis, and Evaluation (Armstrong, n.d.). The athletes in this study were asked to watch the Triad education video and use what knowledge they gained from the video to answer closed-ended questions regarding the Triad. Subsequent levels of Bloom's Taxonomy were initiated by the video intervention, though not measured in the results. Comprehension and Application are two very important next steps to be researched among female athletes following a Triad education intervention. In order to assess Comprehension of Triad education, researchers may include open-ended questions on a post-intervention questionnaire, aimed to assess female athletes' understanding of the Triad. Future education interventions should also look to expand upon Triad education interventions to make them more interactive, and to include cues to action. Cues to action may be any internal or external stimulus that provide the motivation needed to make positive decisions regarding one's health (Armstrong, n.d.). Some cues to action that may stem from a Triad video intervention may include female athletes tracking the length of their menstrual cycles, consuming more snacks throughout the day, or seeking professional help for recognized abnormal eating behaviors. These cues to action represent the Application level of Bloom's taxonomy (Armstrong, n.d.), and may be effectively measured during a future study. The aim of educating female athletes on the Triad is not just to increase their knowledge, but to also prevent future cases of Triad conditions.

Nutrition as it relates to energy balance is often of little concern to the female high school athlete (Petrie, Stover, & Horswill, 2004). Therefore, educating the adults who are partially responsible for the health of the female adolescent athlete may be beneficial in preventing health consequences of the Triad. Because coaches and trainers play such a vital role in the life of the female high school athlete, providing them Triad education and prevention strategies is essential. If more coaches were to be knowledgeable on the disorder, they may be better able to convey the importance of prevention among their athletes. Not only this, but if a coach were to present this information without any understanding of the Triad, he/she would be much less available to their athletes, who many have questions or concerns regarding their own health. Furthermore, coaches and trainers should have even more extensive training and education on the Triad than their athletes so that they may be fully cognizant of signs of the Triad, possibly before the athlete recognizes the signs herself. Future research endeavors may explore the effectiveness of a Triad education video intervention in increasing parent and coach/trainer knowledge of the Triad.

Conclusion

Results of this study underscore the lack of Triad knowledge and prevalence of Triad conditions among female high school athletes, but most impactful were the responses from the athlete participants, themselves. Not only were many of the athletes grateful to have learned of the disorder, some had already recognized their experiencing symptoms of one or more Triad conditions. The true successes of this study were in providing young female athletes techniques to prevent a potentially serious disorder, and in connecting the dots, so to speak, in giving a name to the symptoms many girls were already experiencing. Whether or not these girls already knew their symptoms were abnormal, they are now each aware of the seriousness of the Triad and know of ways to treat and prevent health consequences in the future. With the knowledge provided by the Triad intervention, the 93 adolescent athletes who took part in this study may be more likely to succeed in their athletic careers with the reduced likeliness of experiencing the detriments of low EA, MI, and low BMD. Knowledge is power; female athletes who are provided education on the Triad may be better able to prevent the negative consequences to their sport participation and their health in avoiding conditions of the Triad.

Reference List

American Psychiatric Association. (2013). Diagnostic and statistical manual of mental disorders (5th ed.). Washington, DC: Author.

Armstrong, P. (n.d.). *Bloom's Taxonomy*. Retrieved from: https://cft.vanderbilt.edu/guides-sub-pages/blooms-taxonomy/

Barrack, M. T., Rauh, M. J., & Nichols, J. F. (2008). Prevalence of and Traits Associated with Low BMD among Female Adolescent Runners. *Medicine & Science in Sports & Exercise, 40*(12), 2015-2021. doi:10.1249/MSS.0b013e3181822ea0

Barrack, M. T., Gibbs, J. C., De Souza, M. J., Williams, N. I., Nichols, J. F., Rauh, M. J., & Nattiv, A. (2014). Higher incidence of bone stress injuries with increasing female athlete triad-related risk factors: a prospective multisite study of exercising girls and women. *The American Journal of Sports Medicine, 42*(4), 949-958. doi:10.1177/0363546513520295

Beals, K. A. (2002). Eating Behaviors, Nutritional Status, and Menstrual Function in Elite Female Adolescent Volleyball Players. *Journal of The American Dietetic Association, 102*(9), 1293-1296. doi:10.1016/S0002-8223(02)90285-3

Beckner, B. N., & Record, R. A. (2016). Navigating the thin-ideal in an athletic world: influence of coach communication on female athletes' body image and health choices. *Health Communication, 31*(3), 364-373. doi:10.1080/10410236.2014.957998

Biesecker, A. C., & Martz, D. M. (1999). Impact of coaching style on vulnerability for eating disorders: An analog study. *Eating Disorders, 7,* 235-244. doi: 10.1080/10640269908249289

Brown, K. N., (2015). Proper Fueling to Avoid the Female Athlete Triad. Retrieved from: https://www.youtube.com/watch?v=_gLxCQpbX-Q&index=15&list=LL4dhRtfNwZm02LW3suO8-Ug

Brown, K. N., Wengreen, H. J., & Beals, K. A. (2014). Knowledge of the Female Athlete Triad, and Prevalence of Triad Risk Factors among Female High School Athletes and their Coaches. *Journal of Pediatric & Adolescent Gynecology, 27*(5), 278-282. doi:10.1016/j.jpag.2013.11.014

Brown, K. N., Wengreen, H. J., Beals, K. A.. & Heath, E. M. (2016). Effects of Peer-Education on Knowledge of the Female Athlete Triad Among High School Track and Field Athletes: A Pilot Study. *Women in Sport and Physical Activity, 24(*1), 1-6. doi: 10.1123/wspaj.2014-0058

Carter, J. C., Stewart, D. A., & Fairburn, C. G. (2001). Eating Disorder Examination Questionnaire: Norms for young adolescent girls. *Behav Res Ther, 39*(5):625-32.

Changstrom, B. G., Brou, L., Khodaee, M., Braund, C., & Comstock, R. D. (2015). Epidemiology of stress fracture injuries among US high school athletes, 2005-2006 through 2012-2013. *The American Journal of Sports Medicine, 43*(1), 26-33. doi:10.1177/0363546514562739

Chavez, M., & Insel, T. R. (2007). Eating disorders: National Institute of Mental Health's perspective. *American Psychologist, 62*(3), 159-166. doi:10.1037/0003-066X.62.3.159

Day, Jennifer & Wengreen, Heidi & Heath, Edward. (2016). Prevalence of Low Energy Availability in Collegiate Female Runners and Implementation of Nutrition Education Intervention. *Sports Nutrition and Therapy*. 1. doi:10.4172/2473-6449.1000101.

De La Torre, D. M. & Snell, B. J. (2005). Use of the Preparticipation Physical Exam in Screening for the Female Athlete Triad Among High School Athletes. *Journal of School Nursing, 21*(6), 340-345.

De Souza, M. J., Williams, N. I., Nattiv, A., Joy, E., Misra, M., Loucks, A. B…. McComb, J. (2014). Misunderstanding the Female Athlete Triad: refuting the IOC consensus statement on Relative Energy Deficiency in Sport (RED-S). *Br J Sports Med, 49*(20), 1461-1465. doi: 10.1136/bjsports-2014-093958.

Doyle-Lucas, A. F., & Davy, B. M. (2011). Development and evaluation of an educational intervention program for pre-professional adolescent ballet dancers: nutrition for optimal performance. *Journal of Dance Medicine & Science: Official Publication of the International Association for Dance Medicine & Science*, *15*(2), 65-75.

Eime, R. M., Young, J. A., Harvey, J. T., Charity, M. J., & Payne, W. R. (2013). A systematic review of the psychological and social benefits of participation in sport for children and adolescents: informing development of a conceptual model of health through sport. *The International Journal of Behavioral Nutrition and Physical Activity, 1098*. doi:10.1186/1479-5868-10-98

Feldmann, J. M., Belsha, J. P., Eissa, M. A., & Middleman, A. B. (2011). Female adolescent athletes' awareness of the connection between menstrual status and bone health. *Journal of Pediatric and Adolescent Gynecology, 24(*5), 311-314. doi:10.1016/j.jpag.2011.05.011

Garner, D. M., Olmsted, M. P., Bohr, Y., & Garfinkel, P. E. (1982). The Eating Attitudes Test: Psychometric features and clinical correlates. *Psychological Medicine*, *12*(4), 871-878. doi:10.1017/S0033291700049163

Gibbs, J. C., Williams, N. I., & De Souza, M. J. (2013). Prevalence of Individual and Combined Components of the Female Athlete Triad. *Medicine & Science in Sports & Exercise, 45*(5), 985-996. doi:10.1249/MSS.0b013e31827e1bdc

Greydanus, D. E., & Patel, D. R. (2002). The female athlete. Before and beyond puberty. *Pediatric Clinics of North America, 49*(3), 553.

Greydanus, D. E., Omar, H., & Pratt, H. D. (2010). The adolescent female athlete: current concepts and conundrums. *Pediatric Clinics of North America, 57*(3), 697-718. doi:10.1016/j.pcl.2010.02.005

Heffner, J. L., Ogles, B. M., Gold, E., Marsden, K., & Johnson, M. (2003). Nutrition and eating in female college athletes: A survey of coaches. *Eating Disorders, 11,* 209-220. doi: 10.1080/10640260390218666

Hergenroeder, A. C., De Souza, M. J., & Anding, R. H. (2015). The Female Athlete Triad: Energy Deficiency, Physiologic Consequences, and Treatment. *Adolescent Medicine: State of The Art Reviews, 26*(1), 116-142.

Hoch, A. Z., Pajewski, N. M., Moraski, L., Carrera, G. F., Wilson, C. R., Hoffmann, R. G., & ... Gutterman, D. D. (2009). Prevalence of the Female Athlete Triad in High School Athletes and Sedentary Students. *Clinical Journal of Sport Medicine, 19*(5), 421-428.

Idaho High School Athletic Association Sports Participation Summary. (2017). Retrieved from: http://www.idhsaa.org/

Ihle, R., & Loucks, A. B. (2002). Dose-Response Relationships Between Energy Availability and Bone Turnover in Young Exercising Women. *Journal of Bone Mineral Research, 19*(8), 1231-1239.

International Society for Clinical Densitometry Writing Group for the ISCD Position Development Conference. (2004). Diagnosis of osteoporosis in men, women, and children. *J Clin Densitom, 7*(1), 17-26.

Kennedy, C. L. (2010). A new frontier for women's sports (beyond title IX). *Gender Issues,* (1-2), 78. doi: 10.1007/s1247-010-9091-y

Khosla, S., Oursler, M. J., & Monroe, D. G. (2012). Estrogen and the skeleton. *Trends in Endocrinology & Metabolism, 23*(11), 576-581. doi:10.1016/j.tem.2012.03.008

Kohrt, W. M., Bloomfield, S. A., Little, K. D., Nelson, M. E., & Yingling, V. R. (2004). American College of Sports Medicine Position Stand: physical activity and bone health. *Medicine and Science in Sports and Exercise, 36*(11), 1985-1996.

Kuczmarski, R. J., Ogden, C. L., Guo, S. S., Grummer-Strawn, L. M., Flegal, K. M., Mei, Z., & ... Johnson, C. L. (2002). 2000 CDC Growth Charts for the United States: methods and development. Vital and Health Statistics. Series 11, Data from The National Health Survey, (246), 1-190.

Laine, C. M., & Laine, T. (2013). Diagnosis of Osteoporosis in Children and Adolescents. *European Endocrinology, 9(*2), 141-144.

Loucks, A. B. (2003). Energy availability, not body fatness, regulates reproductive function in women. *Exercise and Sport Sciences Reviews, 31*(3), 144-148.

Loucks, A. B., & Thuma, J. R. (2003). Luteinizing hormone pulsatility is disrupted at a threshold of energy availability in regularly menstruating women. *The Journal of Clinical Endocrinology and Metabolism, 88*(1), 297-311.

Manore, M. M. (1999). Nutritional needs of the female athlete. *Clinics in Sports Medicine, 18*(3), 549-563.

Martinsen, M., & Sundgot-Borgen, J. (2013). Higher prevalence of eating disorders among adolescent elite athletes than controls. *Medicine and Science in Sports and Exercise, 45*(6), 1188-1197. doi:10.1249/MSS.0b013e318281a939

Matzkin, E., Curry, E. J., & Whitlock, K. (2015). Female Athlete Triad: Past, Present, and Future. *The Journal of The American Academy of Orthopaedic Surgeons, 23(*7), 424-432. doi:10.5435/JAAOS-D-14-00168

Melin, A., Tornberg, Å. B., Skouby, S., Faber, J., Ritz, C., Sjödin, A., & Sundgot-Borgen, J. (2014). The LEAF questionnaire: a screening tool for the identification of female athletes at risk for the female athlete triad. *British Journal of Sports Medicine, 48*(7), 724-728. doi:10.1136/bjsports-2013-093240

Morgan, B. L. (1984). Nutritional needs of the female adolescent. *Women & Health, 9*(2-3), 15-28.

Mountjoy, M., Sundgot-Borgen, J., Burke, L., Carter, S., Constantini, N., Lebrun, C. ….Ljungqvist, A. (2014). The IOC consensus statement: beyond the Female Athlete Triad- Relative Energy Deficiency in Sport (RED-S). *Br J Sports Med, 48*(7), 491-497. doi: 10.1136/bjsports-2014-093502

National Collegiate Athletic Association Sports Science Institute, Interassociation Consensus: Diagnosis and Management of Sport-Related Concussion Management Best Practices. (2018). Available at: http://www.ncaa.org/sites/default/files/SSI_ConcussionBestPractices_20170616.pdf

National Federation of State High School Associations, 1969-2014 High School Athletics Participation Survey (2017), available at http://www.nfhs.org/ParticipationStatics/ParticipationStatics.aspx/

National Women's Law Center. (2017a). *Title IX: The Battle for Gender Equity in Athletics in Elementary and Secondary Schools*. [Fact Sheet]. Retrieved from https://nwlc.org/wp-content/uploads/2015/08/Battle-for-GE-in-Elementary-and-Secondary-Schools.pdf

National Women's Law Center. (2017b). *Title IX: The Battle for Gender Equity in Athletics in Colleges and Universities*. [Fact Sheet]. Retrieved from https://nwlc.org/wp-content/uploads/2015/08/Battle-for-GE-in-Colleges-and-Universities.pdf

Nattiv, A., Loucks, A. B., Manore, M. M., Sanborn, C. F., Sundgot-Borgen, J., & Warren, M. P. (2007). American College of Sports Medicine position stand. The female athlete triad. *Medicine and Science in Sports and Exercise, 39*(10), 1867-1882.

Nichols, J. F., Rauh, M. J., Lawson, M. J., Ji, M., & Barkai, H. (2006). Prevalence of the female athlete triad syndrome among high school athletes. *Archives of Pediatrics & Adolescent Medicine, 160(*2), 137-142.

Nichols, J. F., Rauh, M. J., Barrack, M. T., & Barkai, H. (2007). Bone mineral density in female high school athletes: interactions of menstrual function and type of mechanical loading. *Bone, 41*(3), 371-377.

Pernick, Y., Nichols, J. F., Rauh, M. J., Kern, M., Ji, M., Lawson, M. J., & Wilfley, D. (2006). Disordered eating among a multi-racial/ethnic sample of female high-school athletes. *The Journal Of Adolescent Health: Official Publication Of The Society For Adolescent Medicine, 38*(6), 689-695.

Petrie, H. J., Stover, E. A., & Horswill, C. A. (2004). Nutritional concerns for the child and adolescent competitor. *Nutrition (Burbank, Los Angeles County, California.), 20*(7-8), 620-631.

Practice Committee of American Society for Reproductive Medicine. (2008). Current evaluation of amenorrhea. *Fertility and Sterility, 90*(5 Suppl), S219-S225. doi:10.1016/j.fertnstert.2008.08.038

Rauh, M. J., Nichols, J. F., & Barrack, M. T. (2010). Relationships among injury and disordered eating, menstrual dysfunction, and low bone mineral density in high school athletes: a prospective study. *Journal of Athletic Training, 45*(3), 243-252. doi:10.4085/1062-6050-45.3.243

Rome, E. S., Ammerman, S., Rosen, D. S., Keller, R. J., Lock, J., Mammel, K. A., & ... Silber, T. J. (2003). Children and adolescents with eating disorders: the state of the art. *Pediatrics, 111*(1), e98-e108.

Skemp-Arlt, K. M. (2006). Body Image Dissatisfaction and Eating Disturbances Among Children and Adolescents. *The Journal of Physical Education, Recreation & Dance, 77*(1), 45-51.

Stafford, D. E. J. (2005). Altered Hypothalamic-Pituitary-Ovarian Axis Function in Young Female Athletes. *Treat Endocrinol, 4*(3), 147-154.

Stallings, V. A. (1997). Nutritional needs of the exercising child. *World Review of Nutrition and Dietetics,* 8190-97.

Sundgot-Borgen, J. (1993). Prevalence of eating disorders in elite female athletes. *International Journal of Sport Nutrition, 3(*1), 29-40.

Syed, F., & Khosla, S. (2005). Mechanisms of sex steroid effects on bone. *Biochemical & Biophysical Research Communications, 328*(3), 688-696. doi:10.1016/j.bbrc.2004.11.097

Tenforde, A. S., Barrack, M. T., Nattiv, A., & Fredericson, M. (2015). Parallels with the Female Athlete Triad in Male Athletes. *Sports Med, 46*(2), 171-182.

Thein-Nissenbaum, J. M., & Carr, K. E. (2011a). Female athlete triad syndrome in the high school athlete. *Physical Therapy in Sport: Official Journal of The Association of Chartered Physiotherapists in Sports Medicine, 12*(3), 108-116. doi:10.1016/j.ptsp.2011.04.002

Thein-Nissenbaum, J. M., Rauh, M. J., Carr, K. E., Loud, K. J., & McGuine, T. A. (2011b). Associations between disordered eating, menstrual dysfunction, and musculoskeletal injury among high school athletes. *The Journal of Orthopaedic and Sports Physical Therapy, 41*(2), 60-69. doi:10.2519/jospt.2011.3312

Thein-Nissenbaum, J. (2013). Long term consequences of the female athlete triad. *Maturitas, 75*(2), 107-112. doi:10.1016/j.maturitas.2013.02.010

Wahl, R. (1999). Nutrition in the adolescent. *Pediatric Annals, 28*(2), 107-111.

Warburton, D. R., & Bredin, S. D. (2017). Health benefits of physical activity: a systematic review of current systematic reviews. *Current Opinion in Cardiology, 32*(5), 541-556. doi:10.1097/HCO.0000000000000437

Warren, M. P., & Chua, A. T. (2008). Exercise-Induced Amenorrhea and Bone Health in the Adolescent Athlete. *Annals of the New York Academy of Sciences, 1135244-252*. doi:10.1196/annals.1429.025

Weaver, C. M., Gordon, C. M., Janz, K. F., Kalkwarf, H. J., Lappe, J. M., Lewis, R., & ... Zemel, B. S. (2016). The National Osteoporosis Foundation's position statement on peak bone mass development and lifestyle factors: a systematic review and implementation recommendations. *Osteoporosis International, 27*(4), 1281-1386. doi:10.1007/s00198-015-3440-3

Witkop, C. T., & Warren, M. P. (2010). Understanding the Spectrum of the Female Athlete Triad. *Obstetrics & Gynecology, 116*(6), 1444-1448.

Women's Sports Foundation. (2009). *Women's Sports and Physical Activity Facts and Statistics* [Fact Sheet]. Retrieved from https://www.womenssportsfoundation.org/wp-content/uploads/2016/08/wsf-facts-march-2009.pdf

Yen, S. S. (1998) Effects of lifestyle and body composition on the ovary. *Endocrinology Metabolism Clinics of North America, 27*(4), 915-926.

Appendix A

University of Idaho
Office of Research Assurances
Institutional Review Board
875 Perimeter Drive, MS 3010
Moscow ID 83844-3010
Phone: 208-885-6162
Fax: 208-885-5752
irb@uidaho.edu

To: Katie N. Brown

From: Sharon Stoll
Chair, University of Idaho Institutional Review Board

Date: October 06, 2016

Title: Assessing Prevalence of Female Athlete Triad (Triad) Risk Factors, and Changes in Knowledge among Female High School Athletes Following a Brief Triad Educational Intervention.
IRB #: 16-084

Submission Type: Protocol Amendment Request Form

Review Type: Expedite

Protocol Approval Date: 09/29/2016

Protocol Expiration Date: 09/28/2017

The Institutional Review Board has reviewed and **approved** the amendment to your above referenced Protocol.

This amendment is approved for the following modifications:

- Include participants who may be 18 or above, drawing for $25 gift card, and sheet to sign up for future studies

The amendment does not alter the approval period listed above and the study must be renewed at least 30 days before the expiration date if research is to continue beyond that time frame. Should there be significant changes in the protocol anticipated for this project, you are required to submit another protocol amendment request for review by the committee. Any unanticipated/adverse events or problems resulting from this investigation must be reported immediately to the University's Institutional Review Board.

Appendix B

Female Athlete Health Questionnaire

Please be sure to mark your answers **DARK ENOUGH TO READ** and correctly as shown.

Answer Selection: Correct = ● Incorrect = ⊠ ✓ ⊖

1. Have you had absences from your athletic training or participation in competition during the last year due to injuries? O No, not at all O Yes, once or twice O Yes, three or four times O Yes, five times or more	2. If yes, how many days were you absent from athletic training or competition due to injuries in the last year? O 1-7 days O 8-14 days O 15-21 days O 22 days or more
3. If yes, please describe the injuries.	4. How old were you when you had your first period?_____________ ***If you have never menstruated, skip to question 11**
5. Do you use oral contraceptives? O Yes O No	6. If yes, does menstruation stop if you do not use oral contraceptives? O Yes O No
7. How many periods have you had during the last year? O 12 or more O 9-11 O 6-8 O 3-5 O 0-2	8. Have your periods ever stopped for 3 consecutive months or longer? O No, never O Yes, it has happened before O Yes, that is the situation right now
9. Does your menstruation change when you increase your exercise intensity frequency or duration? O Yes O No	10. How accurately do you think you can answer questions about your menstrual periods? O Very accurately. I usually know when my monthly cycle will start. O Fairly accurately. I don't know exactly when it will start, but I would notice if I haven't had a menstrual cycle in a while. O Not very accurately. I don't usually pay attention to my menstrual cycle.
11. How often do you eat during your training and competition season? Every ___________ hours	12. Are you trying to gain or lose weight? O Yes, gain weight O Yes, lose weight O No If yes, how much? __________lbs.

Fill in a circle for each of the following statements:	Always	Usually	Often	Sometimes	Rarely	Never
1. Am terrified about being overweight.	O	O	O	O	O	O
2. Avoid eating when I am hungry.	O	O	O	O	O	O
3. Find myself preoccupied with food	O	O	O	O	O	O
4. Have gone on eating binges where I feel that I may not be able to stop.	O	O	O	O	O	O
5. Cut my food into small pieces.	O	O	O	O	O	O
6. Aware of the calorie content of foods that I eat.	O	O	O	O	O	O
7. Particularly avoid food with a high carbohydrate content (i.e. bread, rice, potatoes, etc.).	O	O	O	O	O	O
8. Feel that others would prefer if I ate more.	O	O	O	O	O	O
9. Vomit after eating.	O	O	O	O	O	O
10. Feel extremely guilty after eating.	O	O	O	O	O	O
11. Am preoccupied with a desire to be thinner.	O	O	O	O	O	O
12. Think about burning up calories when I exercise.	O	O	O	O	O	O
13. Other people think that I am too thin.	O	O	O	O	O	O
14. Am preoccupied with the thought of having fat on my body.	O	O	O	O	O	O
15. Take longer than others to eat my meals.	O	O	O	O	O	O
16. Avoid foods with sugar in them.	O	O	O	O	O	O
17. Eat diet foods.	O	O	O	O	O	O
18. Feel that food controls my life.	O	O	O	O	O	O
19. Display self-control around food.	O	O	O	O	O	O
20. Feel that others pressure me to eat.	O	O	O	O	O	O
21. Give too much time and thought to food.	O	O	O	O	O	O
22. Feel uncomfortable after eating sweets.	O	O	O	O	O	O
23. Engage in dieting behavior.	O	O	O	O	O	O
24. Like to have my stomach empty.	O	O	O	O	O	O
25. Have the impulse to vomit after meals.	O	O	O	O	O	O
26. Enjoy trying rich new foods.	O	O	O	O	O	O
In the past 6 months have you:	Never	Once a month or less	2-3 times a month	Once a week	2-6 times a week	Once a day or more
Gone on eating binges where you feel that you may not be able to stop?*	O	O	O	O	O	O
Ever made yourself sick (vomited) to control your weight or shape?	O	O	O	O	O	O
Ever used laxatives diet pills or diuretics (water pills) to control your weight or shape?	O	O	O	O	O	O
Exercised more than 60 minutes a day to lose or control weight?	O	O	O	O	O	O
Lost 20 pounds or more in the past 6 months	Yes	O	No	O		
*Defined as eating much more than most people would under the same circumstances and feeling that eating is out of control						

Please rate your agreement to the following questions:

	Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree	Don't Know
1. Skipping or losing my period while playing sports is normal and healthy.	O	O	O	O	O	O
2. A menstrual cycle typically occurs every 28 +/- 7 days.	O	O	O	O	O	O
3. I'm not old enough to have weak bones that fracture easily.	O	O	O	O	O	O
4. Female athletes who skip their period may have difficulty become pregnant.	O	O	O	O	O	O
5. Not eating enough calories could cause me to lose or skip my period.	O	O	O	O	O	O
6. Stress fracture risk is not influenced by the amount of calories I consume.	O	O	O	O	O	O
7. An athlete should eat every 2-3 hours during times of training and competition.	O	O	O	O	O	O
8. Stress fractures (very small bone cracks or breaks) occur more often in girls that skip their period.	O	O	O	O	O	O
9. There is no set body fat percentage that is required for optimal athletic performance.	O	O	O	O	O	O
10. Bone loss that occurs when I am in my teens and early twenties is completely reversible.	O	O	O	O	O	O
11. I consume enough calories from my diet to support my health and physical activity.	O	O	O	O	O	O

Which sport/sports to participate in? Please select all that apply: O Soccer O Golf O Cross-county O Tennis O Volleyball O Basketball O Swimming O Track and Field O Cheerleading O Dance/Drill Team O Softball O Gymnastics O Swimming and Diving O Which is your main sport?___________________	Age O 14 O 15 O 16 O 17 O 18 O Other_______________
Height____________	Weight______________

Appendix C

Follow-Up Questionnaire

Please be sure to mark your answers **DARK ENOUGH TO READ** and correctly as shown.

Answer Selection: Correct = ● Incorrect = ☒ ✓ ⊖

Please rate your agreement to the following questions:

	Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree	Don't Know
1. Skipping or losing my period while playing sports is normal and healthy.	O	O	O	O	O	O
2. A menstrual cycle typically occurs every 28 +/- 7 days.	O	O	O	O	O	O
3. I'm not old enough to have weak bones that fracture easily.	O	O	O	O	O	O
4. Female athletes who skip their period may have difficulty become pregnant.	O	O	O	O	O	O
5. Not eating enough calories could cause me to lose or skip my period.	O	O	O	O	O	O
6. Stress fracture risk is not influenced by the amount of calories I consume.	O	O	O	O	O	O
7. An athlete should eat every 2-3 hours during times of training and competition.	O	O	O	O	O	O
8. Stress fractures (very small bone cracks or breaks) occur more often in girls that skip their period.	O	O	O	O	O	O
9. There is no set body fat percentage that is required for optimal athletic performance.	O	O	O	O	O	O
10. Bone loss that occurs when I am in my teens and early twenties is completely reversible.	O	O	O	O	O	O
11. I consume enough calories from my diet to support my health and physical activity.	O	O	O	O	O	O
12. I feel that this sport nutrition education was of value to me.	O	O	O	O	O	O
13. I can use the information that I learned and apply to my own personal health.	O	O	O	O	O	O

Do you have any feedback about the sport nutrition education you were presented? In the pace provided below, please provide any comments you may have:

Appendix D

PARENTAL CONSENT/ CHILD ASSENT FORM

Female Athlete Health Study

Purpose of Study:

Dr. Katie Brown and graduate student Rachel Krick from the University of Idaho School of Family and Consumer Sciences are conducting a research study in order to evaluate female high school athletes' knowledge of their health in relation to their physical activity.

Study Procedures:

As a participant, your daughter will be asked to complete a short survey evaluating her understanding of physical activity in relation to health. This survey will contain questions about her awareness and knowledge of health concerns that are specific to female athletes, as well as a few questions about her own health and nutrition routines. After completing the initial survey, she will then take part in a brief nutrition education intervention and lastly take a follow-up survey with nutrition knowledge questions.

Precautions:

Participation in this research study involves only minimal risk. Your daughter may experience some psychological discomfort from revealing information about her health, nutrition and knowledge of health concerns that are specific to female athletes.

Advantages:

Your daughter may benefit from this research study by learning more about her personal health and strategies for improving health and performance. The investigators will gain knowledge from this study about how to promote the health of female high school athletes in the future.

Voluntary Participation & Right to Withdraw:

Your daughter's participation in this research is entirely voluntary. You may refuse to have your daughter/guardian participate, or you may withdraw her from this research without consequence or loss of benefits. Your daughter can also choose to not participate or withdraw at any time without consequence or loss of benefits. This will not affect your daughter/guardian's standing in any class or sports team at Troy High School now or in the future. Your daughter/guardian may participate in the educational intervention without participating in the survey. In order for your daughter to participate in the research study, this form must me signed by both you and your daughter and returned to the coach or researcher.

Confidentiality Policy:

The surveys are anonymous; no identifying information will be collected. Research records will be kept confidential, consistent with federal and state regulations. Only the investigator and research assistant will have access to the data which will be kept on a locked computer in a locked room. This survey is anonymous; no personal, identifiable information will be obtained.

IRB Approval Statement:

The Institutional Review Board for the protection of human participants at the University of Idaho has approved this research study. If you or your daughter have any pertinent questions or concerns about her rights or a research-related injury, you may contact the University of Idaho Office of Research Assurances at (208) 885-6162 or email irb@uidaho.edu.

Questions or Concerns?

If you or your daughter have any questions regarding this research you may contact research assistant Rachel Krick at kric1335@vandals.uidaho.edu or (208) 669-0416 or Dr. Katie Brown at katieb @uidaho.edu or (208) 885-7664.

Signature of PI & Student Researcher

______________________________ ______________________________

Katie Brown, PhD, RDN, LD	Rachel Krick
Principal Investigator	Student Researcher
(208) 885-7664	*(208) 669-0416*
katieb@uidaho.edu	kric1335@vandals.uidaho.edu

Parental Consent

☐ I provide permission for ______________________ to participate in this research study.
(Your daughter's name)

______________________________ ______________________________

Parent/Guardian Signature Date

______________________________ ______________________________

Print Name of Parent/Guardian Relationship to Participant

Child Assent

I have reviewed this consent form and understand and agree to participate in this study.

______________________________ ______________________________

Child Signature Date

____

Print Child Name