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Identifying and Reducing Risk of the Female Athlete Triad in Division 1 Athletes

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IDENTIFYING AND REDUCING RISK OF THE FEMALE ATHLETE TRIAD IN DIVISION I ATHLETES

by

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ABSTRACT

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Despite the well-known health benefits of exercise and physical activity, physically active females are at risk for consuming inadequate energy to support their exercise and physical activity levels [1-4]. Beyond the general population of physically active females, the female athlete is driven to excel in her sport and is often willing to go to any lengths to achieve athletic success, and a lean physique and appearance [1-4]. To achieve this lean physique, many female athletes consume inadequate energy to support their level of exercise [1-4]. These female athletes may not realize that they are consuming inadequate energy [1-4]. Such characteristics may lead to female athletes having low energy availability with or without disordered eating, which may lead to menstrual disturbances and low bone mineral density [5]. These three disorders are collectively referred to as the female athlete triad [5].

Female athletes competing at the collegiate level are extremely busy, therefore, interventions have to place minimal burden on the athlete's time [6]. This series of studies examines the prevalence of the Triad in a Division I track and field program, a new dietary tracking method that allows individuals/athletes to record eating occasions with a smartphone for dietary analysis, placing minimal burden on athletes, and the provision of nutrition education and text message reminders as an intervention strategy to increase energy intake and increase nutrition knowledge about the Triad.

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PUBLIC ABSTRACT

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Physically active females, or female athletes, are at risk for the condition known as the female athlete triad (Triad). The Triad is made up of three components that are distinctly separate, but intertwined: consuming inadequate energy for how much they are exercising, poor bone health, and problems with their menstrual periods. When female athletes don't consume enough energy for how much they exercise, there can be hormonal imbalances, causing the body to conserve energy from some important functions including menstruation, and increased bone turnover resulting in a higher risk of stress fractures and early osteoporosis. Female athletes at risk for the Triad have a higher risk of being injured, and don't have the energy that they need to perform physically.

To combat the Triad, we performed assessments to see how many female athletes were at risk for the Triad in Division I female athletes, and were surprised at the high number that were at risk for the Triad. We provided nutrition information and interventions aimed to decrease female athlete's risk for the Triad. We also developed a new, quick method for female athletes, or busy individuals, to track their diet using the

video feature on their cell phones. The benefits of providing nutrition information to the female athletes included: increasing their knowledge about the Triad, and things that they could do to prevent the Triad. The interventions did cause behavior change in some female athletes to increase how much energy they were consuming, decreasing their risk for the Triad.

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CHAPTER 1

INTRODUCTION AND BACKGROUND

Abstract

The female athlete triad was introduced in 1997, and has evolved over time to include three interrelated components: low energy availability with or without disordered eating, menstrual dysfunction, and low bone mineral density. Low energy availability plays a causal role in the development of the other two components of the female athlete triad. Female athletes participating in sports that emphasize a thin or lean physique are at an increased risk for the female athlete triad. Increasing energy intake as a means of increasing energy availability is the key to lowering risk for the female athlete triad. Interventions providing nutrition education have succeeded in increasing knowledge related to the female athlete triad, but have been unsuccessful at changing dietary behaviors of participants to increase energy intake. Interventions providing a daily dietary supplement supplying additional energy to participants have been successful at increasing energy intake to the point that normal menstruation is resumed. The purpose of this study was to evaluate the prevalence of the female athlete triad in female collegiate athletes, to provide two different types of interventions aimed at improving energy intake, and the development of a new dietary assessment tool allowing participants to record their eating occasions with the video camera built in to their mobile phones and upload their dietary videos to a website where undergraduate students would estimate portion sizes and assess energy intake from their uploaded videos.

Introduction

In 1997 the three components of disordered eating (DE), amenorrhea, and osteoporosis were termed the female athlete triad (Triad) in the inaugural Triad position stand issued by the Task Force on Women's Issues, of the American College of Sports Medicine (ACSM) [1]. To define the original components of the Triad: DE is abnormal patterns of eating that may range from mild abnormal eating behaviors such as episodic fasting, to extreme conditions of eating disorders (ED) including anorexia nervosa and bulimia [2], amenorrhea is the absence of menstrual cycles exceeding three months in an individual that was previously menstruating [3], and osteoporosis is the condition of decreased bone mineral density (BMD) of normally mineralized bone [4], exceeding 2.5 standard deviations below the average BMD of young women [5].

As a result of continuing research conducted proceeding the 1997 Triad position stand, researchers observed negative health consequences of the Triad associated with less severe conditions than the original components of the Triad [6]. An updated position statement was published by the ACSM in 2007, replacing "DE" with "low energy availability (EA) with or without DE," recognizing the existence of inadvertent low EA [7]. EA is defined as the dietary energy remaining after energy is used to support physical activity, and is the cornerstone of the Triad; amenorrhea and low bone mineral density (BMD) are consequences of low EA [6]. Thus, an energy deficit, whether intentional or not, can lead to low EA and increase risk for the Triad. Exercise training increases the amount of energy expended in activity, while endurance sports can even quadruple the amount of energy used in movement and physical activity [8]. The American College of Sports Medicine (ACSM) states that athletes who expend large amounts of energy in prolonged exercise training can become energy deficient without having an ED, DE, or even dietary restriction of any kind that would result in the previously mentioned inadvertent low EA [8].

The updated position statement also changed the component of "amenorrhea" to "menstrual dysfunction (MD)". The less severe forms of MD (follicular suppression and anovulation) may not display any menstrual symptoms, and female athletes may be unaware that they are experiencing MD [9]. The updated position statement also stated that the Triad was a spectrum of separate, but interrelated components, and that an athlete's condition can fall anywhere on the spectrum ranging from optimal EA to low EA with or without DE, optimal BMD to low BMD and osteoporosis, and normal menstruation to MD, respectively [7]. The existence of any one Triad component can have negative effects and is a red flag to search for other components of the Triad [6, 10].

Physically active females, especially those who participate in sports that place an emphasis on being thin or lean, may restrict their energy intake (EI) to maintain a low body weight (BW) in order to be more successful in their sport [1, 11-13]. Collegiate female athletes participating in competitive sports are a subset of physically active females that may be at an increased risk for the Triad from: increased pressure to be thin and lean from fellow athletes, competitors and coaches, trying to achieve an idealistic, athletic, body type [14, 15], and as a result of an increased level of exercise energy expenditure (EEE) without increasing EI [16].

A meta-analysis of the prevalence of any one or two of the components of the Triad in female athletes participating at any activity level, ranged from 16.0 - 60% and 2.7 - 27% respectively [17]. A study at the high school level observed that 78% of varsity female athletes experienced one or more of the components of the Triad, and approximately 50% of these same athletes reported some form of MD [18]. Other studies have reported prevalence of DE higher than 60% for athletes competing in sports that emphasize being lean and having a low body weight, including cross country, track and field, gymnastics, cheerleading, and dance [14-16].

Proper nutrition leading to increased EI is the key to increasing EA to prevent the Triad [19], and is also considered a large determinant of athletic performance as food is fuel [20]. Thus, low EA should be the primary nutritional concern for today's female athlete, both for their health and safety, and for optimal performance [21].

The 2014 Female Athlete Triad Coalition stresses the importance of an early intervention to prevent the progression to more serious endpoints as a female athlete moves across the continuum from optimal EA to low EA that include: clinical ED, MD (including amenorrhea and infertility), potentially irreversible osteoporosis and low BMD, cardiovascular disease (CVD), endothelial dysfunction, and decreased immunity [6, 22].

Literature Review

The three components of the Triad will be discussed in this literature review, including the mechanisms relating the components to each other. Female athletes may be at an increased risk for the Triad for a myriad of reasons, without even realizing that they are at risk. Risks and vulnerabilities of female athletes falling into the Triad will be discussed following the three interrelated components of the Triad. The interventions that have previously been conducted to reverse low EA related to the Triad will conclude this review.

Low Energy Availability

EA refers to a spectrum of eating behaviors, ranging from optimal EA to low EA, with or without DE [7]. Energy restriction is common in female athletes, ranging from inadvertent and unknowingly consuming inadequate energy to support an increased EEE, to the advertent failure to consume adequate energy due to pathologic restrictive behaviors like EDs [23]. Prolonged energy restriction can lead to low EA [23] and decreased physical performance by negating the effects of physical training [24, 25]

EA is the amount of energy that is available to support metabolic processes after the immediate need for energy to support physical activity is met [26]. EA can then be converted to an Index of EA, which is interpretable against cut points established by Loucks et al. to assess risk for the Triad [26]. An index of EA is defined as EI in kilocalories (kcal) minus EEE in kcal divided by kilograms (kg) of lean body mass

(LBM) /day (d) [6]. The calculation of EA is limited by the error that is associated with the methods of assessing its components: assessing EI, EEE, and LBM [17]. Methods for assessing EA are always improving, but are still imprecise [6]. Methods of analyzing EI, EEE, and body composition to convert EA to an index of EA will be discussed in chapter 2.

When energy levels drop below the recommended index of EA of 45 kcal/kg LBM/d [27], the amount of energy used for reproduction and other physiological functions is reduced to restore energy balance (EB) [7]. When energy levels are below an index of EA of 30 kcal/kg LBM/d in controlled laboratory settings, significant negative changes in reproductive function [28], metabolism, and bone [29] occur to provide EB as the body reverts to survival mode [27]. At this low threshold of EA, endothelial dysfunction, CVD, musculoskeletal complications, and stress fractures may occur [17, 30]. A study by Kopp-Woodroffe et al. found that amenorrheic athletes had individual averages of energy deficit of ranging from 150-650 kcal/d [31].

Women who are physically active should seek to be at or above 45 kcal/kg LBM/d to ensure adequate EA for all physiological functions [7]. Low EA is corrected via increasing EI and adjusting EEE accordingly [6]. Improving EA is central to preventing MD and low BMD among female athletes at risk for the Triad [7, 22].

Low EA with or without DE may occur in female athletes for many reasons, including the following identified by the ACSM: 1) intentional and rational, but mismanaged efforts to reduce body size and fatness, 2) compulsive, or clinical ED 3), and inadvertent failure to increase calories to compensate for the increased amount of EEE

[8]. ACSM recommends that exercising women consume at least 1800-2000 kcal/d [32], and an additional 500-1000 kcal/d is advised [33]. Female athletes may have to eat beyond their appetite to maintain adequate EA, and may be in a state of low EA without realizing it [9].

The challenge of maintaining adequate EA in physically active females is that there is not a strong biological cue to signal the body to increase EI to match EEE when EEE is increased [34]. To make matters worse, feelings of hunger have been observed to be suppressed by exercise [35, 36]. In a study with marathoners, Westerterp et al., observed that a 20% increase in EEE over a 40-week training period did not induce increased feelings of hunger to prompt participants to increase EI to meet their elevated energy needs [37, 38].

In experiments, restriction of a certain amount of kcal consumed increased feelings of hunger, but the same amount of kcal burned during exercise did not increase feelings of hunger [39]. Loucks reported that exercising women in the laboratory had to force themselves to eat much past their appetite to consume the amount of energy needed to compensate for their EEE, in order to prevent MD [9]. Williams et al. reported having to offer special treats to monkeys with MD to persuade them to increase their EI to a level that would restore menstruation [40]. Because appetite and hunger are not reliable cues for athletes to increase their EI to meet energy demands, it is recommended that athletes eat by discipline to consume sufficient energy beyond their hunger cues to increase EI to maximize performance and health, and to avoid risk for low EA and the Triad [9].

Female athletes have other barriers influencing their EI beyond inadvertent under consumption of EI, or under consumption to improve BW for performance purposes. More young female athletes have reported that it is the improvement of appearance rather than improvement of performance that drove their decision to diet [41]. Thus, issues unrelated to sports may need to be addressed to influence female athletes to eat appropriately for their elevated EEE [8].

Even when female athletes understand proper eating behaviors, their desire to improve their appearance and performance have been observed to be more important than their dietary decisions [41]. Competitive female athletes have many characteristics that are similar to those with EDs: they will work tirelessly to try and achieve an unrealistic or unachievable body shape, have a weight preoccupation, impose rigid dieting, are tough minded, have high levels of self-control, and desire to please coach, parents, etc. [42]. It is these same traits that lead to successful athletic performance, but they make it difficult to identify and treat those athletes with ED [42]. These traits are valued in the athletic realm, and can easily be misperceived by medical personnel and the athlete as assets to sport, rather than symptoms [42].

Female athletes are also extremely busy, and may find it hard to fit in times to eat around school and intense practices and competitions [43]. Busy schedules, increased stress, disinterest in food, placing eating as a lower priority, large amounts of time spent traveling may also contribute to decreased EI, as well as participating in eccentric eating habits, like eating the same thing on a daily basis, or certain meals as part of the pregame routine [44].

EB is used in the field of dietetics for research and in practice [8]. EB is defined as EI minus total energy expenditure (TEE) and is expressed as EB = EI – TEE [8]. EB is not a useful concept for managing an athlete's diet, because an athlete can be in EB and still be in a state of low EA, as the body restricts energy to other pathways to maintain EB [8]. Optimal treatment of the Triad must be addressed by treating the underlying cause of the triad, which is low EA [7]. Treating low EA is accomplished by increasing EI and possibly decreasing EEE with the goal of increasing EA [7, 22].

Amenorrhea and Menstrual Dysfunction

Severe MD is defined as primary amenorrhea, secondary amenorrhea, and oligomenorrhea [45]. Primary amenorrhea is the delay of menarche after the age of 15 years [3]. Secondary amenorrhea is defined as the absence of menstrual cycles for more than 3 months or 90 d in an individual who has previously menstruated [3, 46]. Secondary amenorrhea is associated with the highest deficiency of estrogen, resulting in severe impact on BMD relative to the effects of other MDs [1, 45]. Prevalence of amenorrhea in female athletes ranges from 1 - 66%, versus 2 - 5% in sedentary females [46]. Oligomenorrhea is defined as inconsistent and irregular menstrual cycles spaced 36 to 90 days apart [46].

For regular menstruation to occur, the hypothalamic gonadotropin releasing hormone (GnRH) must regulate the follicle stimulating hormone (FSH) and the pulsatility of luteinizing hormone (LH) secretion by gonadotrophs in the pituitary gland [23]. Regular pulsatility of LH results in the release of specific levels of estrogen from the ovary [23]. Ovarian function critically depends on the frequency that the pituitary gland secretes LH into the bloodstream [23]. The frequency of the LH pulsatility is influenced by EA, which is the combination of inadequate EI and high EEE, not inadequate EI or high EEE alone [47].

When there is an energy deficit, the regulation of the pulsatility of LH is altered to allow energy to be used for other essential physiological processes [48]; in this way, low EA plays a causal role in MD [40]. When EA is < 30 kcal / kg LBM / d, GnRH hormone secretions from the hypothalamus are affected [25], disrupting the pulsatility of LH [28]. The disruption of LH pulsatility causes levels of LH to decrease, stopping ovulation from being triggered and delaying menstruation [49]. A delay in menstruation results in the decreased release of estrogen [49].

LH pulsatility has been observed to be disrupted at an EA < 30 kcal/kg LBM/d [28]. Loucks and Thuma observed that normal LH pulsatility was maintained during a 33% reduction in EA at 30 kcal / kg LBM / d, demonstrating that LH pulsatility is not linearly proportional to EA, but is abruptly disrupted at a threshold of EA of 30 kcal / kg LBM / d or lower [28]. The disruption of LH pulsatility becomes progressively worse as EA declines [29]. Loucks stated that these results supported the hypothesis that reproductive function reflects the availability of metabolic fuels, and that athletes may be able to avoid MD by maintaining their EAs above 30 kcal / kg LBM / d [9].

A study by Loucks regarding EA and its effect on reproductive function in nine women aged 18-29 years who were regularly exercising and who were also regularly menstruating and in good health provided some interesting results [47]. The effect of low

EA on the frequency of LH pulsatility and the metabolic hormones in the women when they were placed in a state of low EA from exercise was smaller than when the same women were placed in a state of low EA from restricting EI [47]. In this study, the same level of EA was induced in each group by exercise or restricted EI [47]. The increased effect on LH pulsatility from low EA as a result of restricted EI came as an unexpected surprise to researchers [47]. Exercise seems to have a protective effect on reproductive function, as the exercising group had a higher level of carbohydrates available, possibly as the result of skeletal muscle undergoing an alteration to spare glucose during low EA [47]. Thus, energy lost from dietary restriction resulted in a greater disruption of LH pulsatility than energy lost with exercise-induced low EA [47].

Diving deeper into reproductive function and EA, Loucks explains that it is not general EA that reproductive function depends on, but brain glucose availability (or liver glycogen stores), specifically [9]. Fatty acids cannot cross the blood-brain barrier, resulting in the large and metabolically active brain relying on glucose for energy [9]. Daily glucose requirements for the brain exceed the glycogen stored in the liver, and glucose cannot be pulled from muscle glycogen because muscle cannot release glycogen back into the bloodstream [9]. Skeletal muscle also has access to liver glycogen stores and can use large amounts of liver glycogen in intense activity, competing directly with the brain for glycogen [9]. Loucks describes that working muscle in a marathon uses as much glucose in a 2-hour period as the brain would use in a week [9]. Research suggests that normal reproductive function depends on brain glucose availability rather than EA in general [9]. Loucks concludes that athletes burning large amounts of energy through exercise training can induce MD without an ED or DE, but the energy deficiency still impairs performance, growth, and health [9].

Metabolic changes occur in amenorrheic athletes, and include: increased growth hormone, peptide YY, ghrelin, mildly elevated cortisol, and decreased levels of leptin and insulin-like growth factor 1(IGF-1), which are signs of chronic energy deficiency and lead the body to conserve energy and delay menstruation awaiting a later influx of dietary energy [50, 51]. Prolonged reproductive suppression can lead to hypoestrogenemia, which can impact cardiovascular health and lead to musculoskeletal injuries [52].

The prevalence of amenorrhea is elevated in women who restrict EI, or who exercise intensely without the replacement of the kcal expended in exercise [1]. Otis et al. discovered that the prevalence of amenorrhea is higher in endurance and aesthetic sports, and can be up to ten times higher than has been observed in the general population [1]. After the publication of the 1997 Triad position stand, researchers identified negative consequences of the Triad associated with less severe subclinical MD that are not as severe as amenorrhea [6]. These subclinical forms of MD include: follicular suppression, luteal suppression and anovulation [9]. These subclinical forms of MD do not cause any menstrual symptoms; female athletes with subclinical MD would be unaware that they are experiencing MD and are at increased risk for the Triad [9].

In a study of 46 female runners aged 18-36 years who were in good health and menstruating regularly, De Souza et al. reported high incidence of these subclinical forms of MD [53]. De Souza et al. reported that 78% of female runners who experienced regular menstruation had luteal suppression and anovulation in at least one of three months [53]. Other studies suggest that almost half of exercising women experience some form of subclinical MD [54].

The method of self-reported menstrual history can only identify MD in those who are experiencing the loss of menses for more than 3 months (functional hypothalamic amenorrhea) or any irregularities in the length of their cycle of menstruation (oligomenorrhea) [54]. As a result, De Souza et al. state that self-reported methods of MD are likely underestimating the number of women MD, and are, therefore, underestimating the prevalence of the Triad [54].

Many female athletes may not be concerned with their MD, but the decline in estrogen that is related to the LH suppression can compromise their attainment and maintenance of BMD throughout their life, and result in an unfavorable lipid profile with high markers of inflammation related to MD and decreased levels of estrogen [55]. Amenorrheic women are often infertile, because they do not have follicular development, ovulation or luteal function occurring [7]. Subclinical forms of MD including luteal deficiency may also result in infertility as a result of low follicular development or the failure of implantation [7].

Oral contraceptive therapy (OCT) is commonly prescribed to female athletes presenting with amenorrhea, to reverse MD and address low BMD [56]. OCT may help regulate menstruation, but does not correct the underlying problem of low EA in amenorrheic females, which is altering bone formation and bone health [57]. Dietary supplementation to increase EI in exercising females prevents low EA from disrupting LH pulsatility [31, 58]. Dietary supplementation to increase kcal intake alone, without changing the amount or intensity of exercise has been observed to restore normal menstruation in a study involving monkeys who had exercise-induced amenorrhea [40].

Low Bone Mineral Density

History of MD and low EA increases the risk of developing low BMD [59]. Metabolic fuels in low EA are unavailable for many important physiological processes, including bone tissue turnover [9]. A 10% decrease in body weight has been shown to result in a 1 - 2% loss in BMD [60]. Bone is dynamic tissue that is always being remodeled [29]. This occurs through bone resorption (osteoclasts), and bone formation (osteoblasts) [29].

The level of peak bone mass (PBM) attained in early years is a strong predictor of fracture risk and osteoporosis later in life [61]; it is essential to maximize PBM accrual to maintain bone health over time [62]. This is disconcerting, as 50% of PBM is deposited during teenage years [9]. A female in energy deficiency during this crucial time for attaining PBM will have the rate of bone formation lowered via suppression of reproductive hormones [9]. The demineralization of bone in these energy deficient young women leads to amenorrheic female athletes with the BMDs similar to 60 year old post-menopausal women [9].

Amenorrheic athletes experience lower levels of estrogen, or hypoestrogenemia, as a result of the disruption of LH pulsatility from low EA, which was discussed in the section on amenorrhea and MD. This has a negative effect on bone turnover, as the main role of estrogen with regard to bone, is suppression of osteoclast activity to prevent the uncontrolled breakdown of bone [29]. Both low EA and hypoestrogenism have independent and cumulative effects on bone health and accrual of PBM [23].

Upon observation that low BMD in amenorrheic women did not increase or normalize after estrogen therapy or upon return of menstruation, researchers believed that some cases of chronic low BMD may be irreversible or that there may be an estrogen-independent mechanism behind low BMD in females with low EA [1, 29, 63]. Weight gain has successfully been observed to have positive effects on increasing BMD, but the same positive effects have not been observed in amenorrheic athletes placed on oral contraceptives who did not increase EA [1]. Low BMD has also been observed in female athletes who were experiencing regular menstruation while suffering from an ED, suggesting that some mechanisms of BMD are not tied to menstruation and estrogen but to EA [64].

Estradiol (serum estrogen) levels are one of the most important factors that ensures positive bone metabolism, because of its anti-resorptive function [65]. Ihle and Loucks observed that the rate of bone formation, and hormones associated with bone formation were suppressed within 5 d of EA being reduced from 45 kcal/kg LBM/d to 30 kcal/kg LBM/d [29]. When EA was restricted severely enough to suppress estradiol at a threshold of < 10 kcal/kg LBM/d, bone resorption increased and overwhelmed bone deposition in as few as 5 d [29]. At this low level of EA, bone remodeling became increasingly uncoupled as osteoblasts and osteoclasts were no longer balanced, and bone resorption increased dramatically [29]. If this level of EA reduction was maintained, irreversible reductions in BMD may occur [29]. Keen and Drinkwater observed that after normal menstruation had been resumed for 6 years, lumbar spine BMD was only 85% as dense compared to athletes who had no history of MD [66].

Hormones involved in signaling EA seem to have an impact on bone metabolism; these hormones include: ghrelin, leptin, peptide YY, adiponectin, insulin, and cortisol [62]. Amenorrheic athletes have lower levels of leptin, higher levels of cortisol and ghrelin, and lower levels of FSH, estradiol, 3,5,3'-triiodothryonine (T3), progesterone, insulin and lower levels of bioavailable IGF-1 [62]. Testosterone, leptin, catecholamines, parathyroid hormone and other hormones are also known to play a role in bone turnover and the achievement of PBM [62]. The effect of many of these hormones on bone health and the accrual of PBM are still under investigation to understand the mechanisms [62]. Athletes in a state of low EA typically are under consuming important vitamins and minerals; deficiencies in nutrients like calcium and vitamin D negatively affect bone health independent of menstruation status [45]. Deficiencies in calcium and vitamin combined with low EA can have an additive detrimental effect on BMD [45].

Increased duration of amenorrhea in female athletes results in lower BMD, and may negate the positive effects of exercise on improving BMD and skeletal health [23]. The combination of low EA, amenorrhea, and intense workouts, increases the likelihood of stress fractures [23]. Another frightening statistic is that a bone mass loss of 2 - 6% per year may occur instead of accruing bone mass in young amenorrheic athletes, leading to a much higher risk (up to 3 times higher), of the development of a stress fracture [67].

Lack of PBM accrual during the critical window of adolescence typically is irreversible; pre- and post- menopause, these women will "withdraw" bone from an already depleted bone bank with devastating effects [68]. It is uncommon for athletes to seek assistance in response to amenorrhea, because most believe that amenorrhea is not harmful and medical treatment is not sought until they sustain a stress fracture; this is often the first sign to medical personnel of risk of the Triad in this population [56].

Vulnerabilities of female athletes towards the Triad

The westernized culture has fueled the false belief that being thin is preferred, and indicates enhanced levels of power, self-control, and success [69]. This false belief has caused body dissatisfaction to become widespread among females, with a higher prevalence among female athletes [70]. Athletes tend to focus intensely on body appearance with a quest for the "ideal" body composition or shape [7, 14, 70]. This quest ultimately leads to body dissatisfaction and decreased energy consumption [7, 14, 70].

Female athletes are at an increased risk for developing the Triad as a result of exposure to many societal pressures to be thin (teammates, judges) and focus on social comparisons, revealing uniforms, and false belief that a lower body weight will enhance performance [7, 14, 70]. Coaches are the first line of information for most female athletes, and knowledge about the Triad is lacking among coaches [71]. Most coaches unknowingly increase the risk of the Triad in athletes as they praise weight loss, and believe that there is an ideal body type for sport and performance and that once an athletes has stopped menstruating, they have reached their ideal BW and body composition [72]. Female athletes may also hide their DE or knowledge of their amenorrhea or MD due to fear of backlash from coaches, or the possibility of missing competitions or as a sign of weakness [73]. If the female athlete is seeking a lower BW as a way to improve performance or to please a coach or parent, this desire may overrule the health consequences of the Triad to the female athlete [74]. Some coaches believe that lower BW and BF leads to more competitive athletes, and that missing periods is an advantage for their athlete [73].

Parents may also negatively impact an athlete's eating behavior by placing value in thinness and weight concerns, or modeling dieting behaviors [75]. Parents may create expectations for their child to be thin, which may contribute to DE behavior [76]. Smolak et al. noted that parental input and comments about weight and food were a large contributor to body dissatisfaction in their children [75], and Heinberg found that kids with higher levels of body dissatisfaction had a higher chance of having parents who made negative comments about their child's eating habits, BW, and their body shape or size [77]. Female athletes may engage in additional social comparison to others when they feel that being thin or lean is important to their parents, coaches, teammates and friends [76, 78]. Coaches, parents, friends, and teammates may be putting pressure on female athletes to look a certain way, and in the female athlete's limited amount of time and resources, female athletes are trying to achieve just that by restricting EI [78].

There are similarities between characteristics of anorexia nervosa and athletes termed "good athletes," which can be pathological and unhealthy and may also contribute to success in the sports sphere [42]. Some of these shared traits include: perfectionism and pursuit of excellence, mental toughness, excessive exercise and commitment to training, over compliance and coachability, selflessness and performance despite pain and denial of discomfort [42].

These shared traits make it difficult to identify athletes with DE or those who may be at risk of developing these behaviors [42]. Thompson and Sherman conclude that the athlete who is willing to work excessively, deny pain and injury and is selflessly committed and complies entirely to coaching instruction is always willing to lose weight to be "better", and is EXACTLY what a coach is looking for in an athlete [42]. Because these characteristics are the norm in the sporting world and are reinforced and encouraged, it can be difficult for coaches and athletes to accept and understand that these characteristics can be unhealthy and should be altered, as they believe doing so may make the athlete less competitive or less accomplished in their respective sport [42].

Female athletes may also be consuming inadequate energy inadvertently, without being aware that they are not consuming adequate energy to support their high EEE [9]. Additionally, energy burned during exercise is not felt as hunger to athletes where the same loss of energy through dietary restriction is felt as hunger [39]. Female athletes may be eating until they are full and may not be trying to restrict their EI or under consuming energy [9].

Interventions

Most intervention programs for DE have been education- and instruction-based with passive participation by participants; research by Stice and Shaw indicates that interactive programs have improved results at decreasing DE [79]. Low EA is the cornerstone of the Triad, and increasing EI to improve EA should be the focus of interventions to improve risk for the Triad [80]. Abood et al. highlights that athletes have a finite amount of time in their athletic/academic schedule, which requires interventions to be efficient, and may limit opportunities to interact formally with athletes [81].

Table 1-1 summarizes the six nutrition education interventions that have been conducted with female athletes with the goal of lowering the participant's risk for the Triad. Four of the studies provided nutrition education as the intervention [81-84]; nutrition knowledge increased in all of the studies, but there was no observed change in EI [81-84].

Table 1-2 summarizes interventions that incorporated dietary supplements to increase EI as an intervention for low EA. Two interventions provided a dietary supplement providing kcals and protein to aid participants in increasing the amount of energy consumed per d [31, 58]. An increase of BW was observed, 1.6 kg after 6 months [58], and 1 kg after 8 weeks [31] after consuming the dietary supplement, respectively.

The study by Kopp-Woodroffe et al. observed the return of menses to three out of four (75%) amenorrheic participants after consuming the additional calories provided by the dietary supplement, as well as limiting physical training by taking one day off a week for rest [31]. All participants with MD in the study by Cialdella-Kam et al. resumed menses, but it was observed that those who had experienced MD > 8 months took longer to resume menses and had lower BMD than those with MD for < 8 months [58]. Cialdella-Kam et al. observed that baseline EA was similar between the MD group and the normal menstruating controls, suggesting that some MD athletes are more sensitive to

EA fluctuations [58]. Both studies concluded that as additional energy was consumed and athletes experienced a moderate weight gain, the body was able to support menstrual function, and the use of a dietary supplement improved EI [31, 58].

Limitations in the study by Kopp-Woodroffe et al. included the lack of a control group to see if amenorrhea was spontaneously reversed, and the small number of amenorrheic athletes that participated in the study [31]. Kopp-Woodroffe et al. recommend research in a larger group of amenorrheic athletes with a control group [31]. Cialdella–Kam et al. conclude that a dietary intervention improves EA and EB and could be a non-pharmacological approach to treat MD and the Triad [58].

The study by Mallinson et al. included two female athletes who had short (3 months), and long (11 months) duration amenorrhea. Both participants increased their EI 20-30% above baseline total energy expenditure (resting energy expenditure + purposeful EEE) while they maintained their normal exercise regimen. Energy bars providing 250-300 kcal were provided to participants to increase EI. Participant 1 (short duration amenorrheic), increased her mean EI by 276 kcal / d, resumed menses in 23 d of the intervention, and gained 4.2 kg (8%) over 52 weeks. Participant 2 (long duration amenorrheic), increased mean EI by 1,881 kcal / d, and resumed menses 74 d into the intervention, and gained 2.8 kg (5%) after 52 weeks [85].

The study by Mallinson et al. was successful in reversing amenorrhea via increasing EI without decreasing EEE, which may be an attractive strategy to coaches and athletes to combat the Triad. Resumption of menses was reported to coincide closely with weight gain and energy status associated with increased EI. Researchers recommend additional research in larger samples of amenorrheic athletes [85].

Conclusion

Collegiate female athletes are at an increased risk for the Triad due to an added emphasis on being thin or lean as a result of pressure from those associated with their sport, including teammates and coaches [7, 14, 70]. These athletes have a misbelief that there is a set "optimal" level of BF or BW that will enhance their performance, and appearance and that this optimal level of BF is achieved when menstruation ceases, which is usually the first sign of the Triad [86]. Athletes may be trying to achieve an" ideal" body composition or shape, leading to body dissatisfaction, ultimately resulting in decreased EI and low EA [7, 14, 70]. Feelings of hunger may be reduced in this population as a result of strenuous exercise [35, 36]. To compound the hunger suppression from exercise, an energy deficit from burning calories is not felt as hunger the same as an energy deficit from dieting and removing the same amount of calories is felt as hunger [34]. As a result, female athletes may be eating until they feel full, and may still be inadvertently have inadequate EI to support their exercise regimen because the body lacks any biological cue to increase EI to support increased EEE [34].

Regardless of the cause of low EI, prolonged low EI will lead to low EA, resulting in increased risk of developing the other components of the Triad (MD and low BMD) [23], and decreased physical performance [24, 25]. If uncorrected, low EA can lead to more severe forms of MD and low BMD, including amenorrhea, stress fractures and possibly irreversible premature osteoporosis, CVD and decreased immunity [6, 22]. The provision of nutrition education to female athletes thus far has been successful at increasing nutrition knowledge, but has been unsuccessful in influencing eating behaviors to increase EI to combat low EA [81-84]. Interventions providing dietary supplements to increase average daily EI have been successful in increasing EA to the point where menstruation is resumed in amenorrheic athletes [31, 58].

An intervention is needed to improve daily, "natural" eating behaviors to increase EI and EA in collegiate female athletes in free living situations where dietary supplementation is not provided. Nutrition education specific to the Triad, presented by dietetic students as well as fellow teammates may aid in increasing knowledge and increasing EI. Daily reminders to increase EI may also be of value, as low EI and EA maybe inadvertent, and would aid in reminding athletes to eat during their busy athletic/academic schedule. Reminders may also be helpful to assist athletes to eat when they do not feel hunger, as this eating cue may be suppressed with exercise. Female collegiate athletes are involved in strenuous training and rigorous travel schedules as well as in academic endeavors and have little time to track their EI [87]. Thus, a dietary assessment tool that can be accessed via a smartphone and require minimal time to record eating occasions (EO) and limit the burden of estimating portion sizes and the need to recall EI at the end of the day would be beneficial to this population [87].

The work described in this dissertation assessed the prevalence of the Triad in Division I track and field athletes at USU and provided two different types of interventions aimed at increasing EA in female collegiate athletes through: 1.) nutrition education provided by dietetic students who were also teammates at USU to female track and field athletes in 2011, 2.) brief nutrition education along with text message reminders sent to female athlete's mobile devices to remind athletes to eat at self-selected times . A dietary assessment tool was also developed allowing participants to record their EOs with their mobile devices to be uploaded to a website where dietetic students would evaluate the nutritional content of their dietary selections. This type of dietary assessment would take a limited amount of time for an athlete to complete, and would decrease the burden of recording EI from the athlete than any other dietary method to date.

Table 1-1: Nutrition education interventions for the Triad

Authors	Year	Intervention Component(s)	Measurement Type	Results	Number of Participants
Collison [82]	1996	Nutrition Education in female college athletes (N = 28) and female non-athletes (N = 32)	Survey data and 3-d food diaries	Significant increase in athlete's scores for knowledge and attitude between pre, post and retention tests ($p < 0.005$). no significant impact on dietary practices	N = 60
Potter & Wood [83]	1991	Self- and group instruction of nutrition education (4 modules)	Pre/posttest	Self-instruction had a significantly higher posttest score than the group instruction ($p < 0.001$)	N = 46
Chapman & Toma [84]	1997	Nutrition education - 2 x 45 minute lectures	Pre/post- 24 hr. recall Pre/posttest "Nutrition Knowledge and Attitude Questionnaire"	Intervention (I) group: Posttest scores showed a significant difference in nutrition knowledge pre- and post-nutrition education ($p < 0.01$), but no improvement in EI or food choices	N = 72
Abood et al. [81]	2004	Nutrition education: nutrition knowledge and self-efficacy	Pre/posttest using nutrition knowledge and self-efficacy questionnaires, 3-d diet record	**I:** significantly improved nutrition knowledge and self-efficacy post-nutrition education ($p < 0.05$), but no change in EI.	N = 30

Table 1-2: Supplementation interventions for the Triad

Authors	Year	Intervention Component(s)	Measurement Type	Results		Length of study
Cialdella – Kam, et al. [58]	2014	carbohydrate-protein supplement (+360 kcal/d)	Pre/post reproductive, thyroid hormones, 7-d food/activity records	EI increased to reverse MD, no significant change in EI (+382 kcal/d) Moderate weight gain (1.6 kg)	N = 18	24 weeks
Kopp-Woodroffe, et al. [31]	1999	Carbohydrate-protein supplement (Gatorade +360 kcal/d, 17 g protein) and 1 d of rest/week	Pre/post 7-d weighed food/activity record to determine EB	1 kg weight gain in each athlete, increase in mean 7-d EI for each athlete. 3 participants resumed menstrual function	N = 4	20 weeks
Mallinson, et al. [85]	2013	Provided energy bars containing 250-300 kcal to increase EI in amenorrheic athletes (increase EI 20-30% above baseline total energy expenditure)	Monitored menstrual function daily, total BW, and Eating Disorder Inventory – 2, 3-d diet	Participant 1: (amenorrheic 3 months) increased mean EI by 276 kcal/d, gained 4.2 kg. Resumed menses 23 days into intervention Participant 2 (amenorrheic 11 months) increased mean EI by 1,881 kcal/d, gained 2.8 kg resumed menses 74 days into intervention	N = 2	56 weeks

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CHAPTER 2

PREVALENCE OF LOW ENERGY AVAILABILITY IN COLLEGIATE FEMALE RUNNERS AND IMPLEMENTATION OF NUTRITION EDUCATION INTERVENTION[1]

Abstract

This study examined the prevalence of low energy availability in a sample of female collegiate athletes (N = 25), then delivered nutrition education related to the female athlete triad and assessed change in knowledge and dietary behaviors. Average energy intake was assessed pre- and post-education using Automated Self-Administered 24-Hour Dietary Recalls. We assessed body composition with multiple-site skinfold measures. Exercise energy expenditure was assessed with accelerometers and a physical activity diary over a 3-day period. A 73-item questionnaire was used to assess knowledge and behavior changes. At baseline, 92% had an index of energy availability < 45 kilocalories /kilogram of fat free mass/d. 40% of participants were amenorrheic, and 32% had a history of stress fractures. There was an increase in summed nutrition knowledge, post-nutrition education (p = 0.001), but no increase in EI (p = 0.979). Low energy availability was common in this sample of female collegiate track athletes, but did not improve with a targeted intervention.

Literature Review

Physically active females, especially those who participate in sports that may place an emphasis on being thin, may restrict their dietary intake to maintain a low body weight [1]. Many athletes are unaware of the amount of energy needed to support basic physiological functions as well as high levels of physical activity. These physically active females, in sports with pressure to be thin are at an increased risk of developing components of the female athlete triad (Triad) [2-5]. One component of the Triad is low energy availability (EA), which is the condition of consuming fewer calories than needed [6]. The other two components, menstrual dysfunction (MD) and low bone mineral density (BMD), are consequences of the condition of having low EA [6].

Low EA is a modifiable risk factor and contributes to decreased physical performance, independent of the consequences related to MD and bone and can negate the effects of physical training [3, 7]. Low EA can contribute to both MD and low BMD [3]. EA is the amount of remaining dietary energy to support physiological functions in the body after energy has been expended through physical activity [6]. This EA is converted to an Index of EA, which is then interpretable against cut points to assess risk for the Triad.

The condition of low EA can be operationalized using the index of EA developed by Ihle and Loucks [8]. The EA index is defined as energy intake (EI) in kilocalories (kcal) minus exercise energy expenditure (EEE) in kcal, divided by kilograms (kg) of fat free mass (FFM) per day (d) [6]. An EA index less than 45 kcals/kg of FFM/d [9], has been associated with physiological changes to reduce the amount of energy used for reproduction and other physiological functions as an attempt to restore energy balance (EB) [10]. When EI is below an index of EA of 30 kcal/kg of FFM/d in controlled laboratory settings, significant negative changes in reproductive function [11], and metabolism and bone [8] occur to provide an EB as the body is placed in survival mode [9].

Women who are physically active should seek to be at or above 45 kcal/kg of FFM/d to ensure they have adequate EA for healthy physiological functions [10]. Low EA must be corrected by increasing EI and adjusting physical activity expenditure [6]. Improving EA is central to preventing MD and low BMD among female athletes at risk for the Triad [12]. The existence of any one Triad component can be detrimental and should prompt an investigation for the other Triad components [6]. The 2014 Female Athlete Triad Coalition stresses the importance of an early intervention to prevent the progression of more serious endpoints that include: subclinical eating disorders (ED) and low EA, amenorrhea and osteoporosis [6].

Positive correlations have been observed between dieting behavior and general nutrition knowledge in female athletes [12, 13]; however, few studies have assessed the effect of nutrition education in female collegiate athletes. In a study using the Eating Attitudes Test-26 (EAT-26), which is used to determine risk for disordered eating (DE), it was observed that the level of nutrition knowledge that an athlete possessed had a positive influence on their eating behaviors [14]. Another educational intervention study conducted by Zawila et al. concluded that female athletes either do not have adequate nutrition knowledge, or they simply choose not to comply with the knowledge they possess [15]. Zawila et al. also stated that the female athlete may be receptive to nutrition education, and that the potential for behavior change toward better eating habits may exist [15].

The objectives of this study were to examine the prevalence of low EA and other risk factors of the Triad in a sample of collegiate female athletes and then deliver an education intervention to assess change in knowledge and dietary behaviors. The results of this study will be used to guide the development of future intervention programs to influence dietary behavior change in athletes at risk for the Triad.

Materials and Methods

This study was reviewed and approved by the Utah State University (USU) Institutional review board. A total of 27 out of 35 (77%) female runners from a Division I track and field team at USU consented to participate (Appendix B). Two athletes dropped out of the study, and the remaining 25 of the 27 (93%) athletes completed all of the study assessments. Female distance runners, sprinters, hurdlers, and jumpers were recruited. Other track and field participants were not targeted because runners have an increased risk for energy restriction and other factors that put them at a higher risk for the Triad [5].

Participants underwent body composition measurements, completed two separate 3-d dietary recalls before and after the nutrition education was provided, and they completed a pre/post knowledge questionnaire related to general nutrition and the Triad, before and after the nutrition education was provided. Nutrition education was provided for six weeks. A Registered Dietitian (RD) or undergraduate dietetic student provided the nutrition education once a week on Tuesdays after track practices for 30 minutes in a classroom setting.

Anthropometrics

Height was measured to the nearest centimeter with a portable stadiometer (Charder HM-200P, Taiwan). Participants were instructed to remove shoes and socks for height measurements. Weight was measured with a BODPOD scale to the nearest 0.01 kg, (Body Composition System; Life Measurement Instruments, Concord, CA) with minimal, tight-fitting clothing consisting of a sports bra and spandex bottoms.

Body Composition

A 3-site skinfold (SKF) at the abdomen, thigh, and triceps [16] was measured to calculate the FFM of each participant. SKF measurements were taken on the right side of the body with a calibrated Lange Caliper (Cambridge Scientific Industries, Cambridge, Md.). According to the specifications of Evans and colleagues [16], SKF measurements were completed by a trained researcher. The 3-site SKF equation used was: % body fat (BF) = 8.997 + 0.24658*(3SKF) – 6.343*(gender) – 1.998*(race), with gender coded as female = 0 and male = 1, and race coded as white = 0 and black = 1 [16]. This 3-site equation was developed with female collegiate athletes and was validated against a 4-

component reference model, which is the criterion measure in elite collegiate athletes [16].

Questionnaire

A questionnaire was completed before and after nutrition education was provided to assess change in nutrition related knowledge. The questionnaire contains 73 questions assessing demographics, prior nutrition knowledge, familiarity with the Triad, and questions about body-image and sources of external pressures to be thin (Appendix C).

Triad knowledge was assessed using a modification of questions used by Pantano [17]. Three questions were also added specific to EA. Stress fracture and menstrual history questions were adapted from a screening tool developed by Beals and Hill that has previously been used in the collegiate athlete population [18].

Body dissatisfaction and body distortion were assessed using a body mass index (BMI) –based silhouette matching test (SMT) [19], which was created and validated by Peterson et al [19]. The BMI-SMT is a 27-item interval scale that references four gender-specific BMI based silhouettes [19]. Each box along the scale represents a BMI score from 14-40. Participants select one BMI-silhouette that they feel best reflects her current body image and her ideal body image [19]. The BMI-SMT Test is validated as a measure of body image perceptions, as well as in estimating body weight and BMI scores [20]. Body dissatisfaction scores represent the level of change an athlete would prefer in their body to achieve their ideal BMI and is calculated as perceived ideal BMI – perceived current BMI [19].

Risk for DE was assessed using the Eating Attitudes Test (EAT-26). EAT-26 has been used to assess ED risks in many populations, including athletes [21, 22]. As recommended by the developers of the EAT-26 tool, scores of 20 or above on the Eat-26 assessment indicated ED behaviors [23]. Scores falling below 20 were assessed as low risk for ED behaviors [23]. Risk for DE was determined by an EAT-26 score > 20, along with a low BMI (< 18.5) and any positive answers to certain behavioral questions [24] about the occurrence and frequency of bingeing, vomiting, use of laxatives or diuretics, excessive exercise for weight loss, and the loss of 20 pounds or more in the last six months [25].

Diet

Dietary recalls were completed over a 3-d period by each participant using a web-based automated self-administered 24-hour recall (ASA24) tool for adults to record their intake. The 3-d diet recall included two weekdays and one d from the weekend to capture an average of participant's 'usual' EI. This method is based on the USDA's Multiple-Pass Method that has been validated and has been proven to be accurate in estimating mean total energy in adults [26]. The ASA24 website guides participants through a 24-hour dietary recall via an animated penguin to prompt the participant of any forgotten snacks, drinks or additives [27]. There was a 5-week period between the first and second 3-d dietary recalls.

Exercise

EEE was recorded for a 3-d period using an Actigraph GTX3 triaxial accelerometer (Pensacola, FL, USA). Participants recorded EEE using the accelerometers for the 3-d that their coach believed to be the ‘peak’ training period during the 6 weeks of our study. The 3-d diet that we recorded EEE did not directly align with when participants recorded their EI due to scheduling by the coaches. Triaxial accelerometers worn for at least three ds have shown to be an objective measure of EEE among free-living people [28-30]. The validity and reliability of the GTX3 has been shown to be similar to other accelerometer devices in the laboratory in measurements of daily activities [31]. The accelerometer records integrated acceleration information in raw counts, which provide an estimation of intensity of the vertical, anteroposterior and mediolateral body movements [32, 33].

An accelerometer is a small, light electronic device that was worn on a belt around the participant’s waist. Participants were instructed to wear the accelerometer on the right side of her body, just above the hip [30]. Participants wore the accelerometer during waking hours for three consecutive ds. Participants were instructed to only remove the accelerometer when they showered and slept. EEE was calculated using raw counts or arbitrary units of measurement converted to EEE using the Williams Work-Energy equation [34].

Because accelerometers do not take into account any additional weight load, or movement up an incline, a physical activity diary was kept by participants and additional activities of this nature were analyzed for EEE according to the 2011 Compendium for

Physical Activities [35]. This method of using the Compendium of Physical Activities is recommended by the 2014 Female Athlete Triad Coalition [6] to calculate EEE according to: kcal = metabolic equivalents of task x weight of athlete in kg x duration of activity in hours [35].

Index of EA

EA was calculated by subtracting average daily EEE from the average daily EI and was then converted to an index of EA by dividing EA by kg of FFM [6]. The index of EA was compared to cutoff scores to assess risk for the Triad. The following cutoff scores related to risk for the Triad were defined by Loucks and Thuma: consuming ≥ 45 kcals/kg of FFM / d as being in EB, consuming < 45 kcal/kg of FFM/d is below EB where negative physiological effects may begin to occur and ≤ 30 kcal/kg of FFM/d as restricted EI; hormone pulsatility has been observed to be abruptly disrupted at this threshold [11].

Description of Nutrition Education

Participants were invited to attend six interactive sessions of nutrition education focusing on aspects of the Triad that were taught by either an undergraduate dietetic student following a scripted outline (Appendix D) or an RD from USU. It was important that the undergraduate students presenting were also fellow athletes on the USU track and field team, with the possibility of influencing the social norms regarding the Triad on their team by presenting the nutrition education. Nutrition education sessions were delivered in thirty-minute increments in a classroom setting once a week after participant's completed track and field practice.

The nutrition education intervention curriculum was a modification of curriculum for high school athletes [36]. Session 4, which discusses the importance of a healthy body image, was a modification of previously developed curriculum by Becker et al. [37]. Becker et al. focused their approach on an intervention towards a healthy body image rather than for athletes to seek for a thin body. Two additional sections were added to the original curriculum to explain the body composition tests the athletes would undergo, and an introduction to the study for participants. Education was presented via a PowerPoint presentation with the opportunity for discussion and questions following the presentation (Appendix E). Refer to Table 2-1 for an outline of the curriculum that was provided in our nutrition education sessions.

Table 2-1: Outline of nutrition education

Session	**Curriculum**
1	Introduction to Triad/ EB/ tracking diet/portion sizes
2	Triad: risk factors, side effects
3	Energy and bone health
4	A focus on health: positive body image, EDs, sports nutrition
5	Body composition
6	Introduction to the study and activity monitors

Statistical Analysis

SPSS software was used to complete the statistics for this study. Crosstabs using chi-squared were used to examine associations between categorical values. Mcnemar's statistic was used to compare differences between pre- and post-tests in categorical data, including comparing the proportion of athletes answer to individual questions as correct or not correct. Paired t-tests were used to assess differences between the two sets of EI, naming the three components of the Triad, and to compare the summed change in nutrition knowledge as well as other continuous factors that were measured from the baseline and after nutrition education. Answers to individual knowledge questions were coded as "Correct" answer = 1 and "Incorrect"/"I don't know" = 0. Scores for individual questions were summed to obtain a nutrition knowledge score. We also ran sub-analyses by event and year in school against EA, and body dissatisfaction. Participants were classified into three categories based on index of EA cutoffs, ≤ 30 kcal/kg of FFM/d, < 45 kcal/kg of FFM/d, and ≥ 45 kcal/kg of FFM/d.

Results

96% (24 participants) of participants were white and 4% (1 participant) were African American. Participant's demographics are shown in Table 2-2. The mean age for the sample was 19 years.

Table 2-2: Baseline characteristics of participants (N = 25)

Age, yrs.	19.5 ± 1.8
Height, cm	168.8 ± 4.7
Weight, kg	61.1 ± 6.9
BF, %	22.3 ± 3.3
Desired body weight change in kg	3.1 ± 5.2
BMI[1]	21.4 ± 1.8
Daily EEE, kcal	711.5 ± 524
FFM, kg	47.4 ± 4.8
EA[2]	30.7
EA < 30 kcal/kg of FFM/d	52%
EA < 45 kcal/kg of FFM/d	92%
Grade	
Freshman	44.4%
Sophomore	29.6%
Junior	7.4%
Senior	18.5%
Ethnicity	
White	96%
Black	4%
Event	
Sprint	54.8%
Distance	45.2%

Data are means ± standard deviations
[1] Weight in kg / height in meters²
[2] kcal/kg of FFM/d

EA, MD and History of Stress Fracture

Participant's mean EI was 2211 kcal. The mean index of EA was 30.8 kcal/kg of FFM/d. A large percentage, 92% (23 participants) were below 45 kcal/kg of FFM/d, and 52% (13 participants) were below 30 kcal/kg of FFM/d. Average EA was 1275 ± 733 kcal. No differences were observed between athletes in event groups. The mean index of EA for distance runners was 26.8 ± 16.2 kcal/kg of FFM/d and the index of EA for sprinters was 30.1 ± 14.6 kcal/kg of FFM/d ($p = 0.578$). According to the questionnaire, 40% (10 participants) of the female athletes were amenorrheic, having gone longer than three months without menstruating. 36% (9 participants) were also very irregular in their menstruation, with their menstruation being off by more than 10 d from their anticipated start date. Two participants reported that they were currently using oral contraceptives, but that their menstruation was regular preceding the use of contraceptives earlier this year, and these individuals were not at risk for other factors associated with the Triad. 32% (8 participants) reported having a history of one or more stress fractures.

BMI-SMT Body Dissatisfaction

Pre-intervention mean body dissatisfaction scores showed a positive increase from - 1.74 ± 2.17 to -1.13 ± 1.10 after nutrition education ($p = 0.614$). The category of female athletes with an Index of EA that was < 30 kcal/kg of FFM/d had 11 participants (44%) with a body dissatisfaction score ≥ 1. In the second category, the female athletes with an Index of EA ranging from 30 kcal/kg of FFM/d to 45 kcal/kg of FFM/d had five participants (20%) with a body dissatisfaction score ≥ 1. In the final category where index of EA was > 45 kcal/kg of FFM/d there was one participant (4%) with a body dissatisfaction score ≥ 1.

Pre-Nutrition Education Intervention Triad Knowledge/Questionnaire

76% (19) of participants reported having some degree of previous formal nutrition education in their life. There were no guidelines as to what was viable as nutrition education; this was left to participant's discretion. 60% (15) of participants had never heard of the Triad prior to this study. Only 8% (2) could name all three components of the Triad prior to nutrition education (low EA, low BMD, and MD). 24% (6) could name at least two of the components of the Triad. The most commonly missed question was, "Each athlete has a set body fat percentage they should aim for to maximize their athletic performance," to which the correct answer was false. Only 16% (4) of participants answered this question correctly.

Post-Nutrition Education Intervention Change in Knowledge/Questionnaire

Change in the percent of participants that answered individual nutrition knowledge questions correctly is shown in Table 2-3. There was an increase in summed nutrition knowledge scores from the pre-intervention questionnaire to the post-intervention questionnaire ($p = 0.001$). The mean for the summed nutrition knowledge scores before the nutrition education intervention was 12.8 ± 2.5. The mean for the summed nutrition knowledge scores post-nutrition education intervention was 14.8 ± 1.8.

Several of the observed changes in the percent of participants answering nutrition knowledge were unexpected. 'Exercise/training too much could cause me to lose my period' dropped from 100% (25) to 96% (24). It was also concerning that 40% (10) indicated that there is a set body fat percentage necessary for optimal performance, and 64% (16) thought skipping a period was normal. 52% (13) of participants could list at least two components of the Triad after nutrition education, however, only 48.5% (5) of these listed low EA as one of these components.

Table 2-3: Changes in Triad knowledge (N = 25)

	Pre-intervention		Post-intervention		
Questions	Don't know	Correct	Don't know	Correct	P-value
Age when females build the most bone. **(13-18)**[1]	0%	44.4%	0%	72%	0.125
Skipping my period can make my bones weak. **(True)**	14.8%	70.4%	0%	95.8%	0.125
Stress fractures occur most often in girls that skip their period. **(True)**	22.2%	63%	0%	95.8%	0.125
Not eating enough could cause me to lose my period. **(True)**	7.4%	88.9%	0%	95.8%	0.250
Teenagers with weaker bones will likely still have weaker bones as adults. **(True)**	11.1%	81.5%	0%	95.8%	0.250
I'm not old enough to have weak bones. **(False)**	3.7%	92.6%	0%	95.8%	0.500
Skipping my period is my body's way of saying I'm training too hard. **(True)**	25.9%	40.7%	12.5%	62.5%	0.016
How much I eat does not affect my bone health. **(False)**	11.1%	85.2%	0%	91.7%	> 0.99
I feel that skipping my period while playing sports is normal. **(False)**	7.4%	48.1%	0%	76%	0.063
Exercise/training too much could cause me to lose my period. **(True)**	0%	100%	0%	96%	> 0.99

[1]Correct answer

Not unexpectedly, the response to Triad question “Skipping my period is my body’s way saying I’m training too hard” had a significant change after the nutrition education intervention as it increased from 40.7% of participants answering the question correctly initially, to 62.5% of participants answering it correctly after the intervention ($p = 0.016$).

Diet

Average daily baseline EI from the 3-d diet record for participants was 2211 ± 582 kcal. After nutrition education was provided, average daily EI from the 3-d diet recall was 2208 ± 598 kcal ($p = 0.979$).

EAT-26

All participants scored < 20 on the EAT-26 assessment indicating that none were screened at risk for ED according to the EAT-26 recommendations. No participant answered affirmatively to the behavioral questions regarding DE. The average score for the Eat-26 assessment was 5.9 ± 4.6. EAT-26 scores dropped significantly following the nutrition education intervention from 5.1 ± 3.1 to 2.6 ± 2.3 ($p = 0.003$).

Body Composition

Average body fat (BF) percentage analyzed using the 3-site skinfold method was 22.3% ± 3.3%. Average FFM in kg was 47.4 ± 4.8. We observed a difference between the average BF% between sprinters and distance runners. The average BF% for sprinters was 21.2%, and for distance runners BF% was 24% ($p = 0.029$).

Discussion

A total of 92% of participants had EA ≤ 45 kcal/kg of FFM/d. This is consistent with a study by Barker et al. concluding that the majority of female endurance athletes (88%) were below this same threshold [2]. 52% of participants had an index of EA < 30 kcal/kg of FFM/d, a level at which MD may occur [11], and which may also result in increased bone turnover, putting these athletes at an increased risk for the Triad. No athletes were at risk for DE, which contrasts the 15% reported by Beals and Manore [4].

The mean daily index of EA was 30.8 kcal/kg of FFM/d which is far below the optimal level of 45 kcal/kg of FFM/d. There is a great need for an intervention and early prevention in this population.

Around two thirds of our population had some form of MD. These results were higher than other similar studies had reported. A study by Beals and Manore found that menstrual irregularity was reported by about one third of female athletes participating in their study [4], and that only 6% self-reported that they were amenorrheic [4], compared to 40% in this study. Another study by Beals and Hill found that MD was reported by 26% of athletes [18], again much lower than was seen in this study.

In the current study, 32% of participants reported having a history of one or more stress fractures. In the study by Beals and Hill, 18.75% of athletes reported having a history of stress fractures [18]. These findings indicate that risk markers for the Triad are higher in our participants than was found in other studies.

Although we observed an increase in nutritional knowledge when knowledge scores were summed over all questions, we did not observe a change in their eating behavior. Average daily baseline EI from the 3-d diet recall for participant's was 2211 ± 582 kcal. After nutrition education was provided, average daily EI from the 3-d diet recall was 2208 ± 598 kcal ($p = 0.979$). Another nutrition education intervention study for collegiate female athletes conducted by Abood et al. had similar results, ($n = 15$) observing an increase in nutrition knowledge from pre-test to post-test, while the mean EI pre-test was 1969 kcal and post-test was 1974 kcal with little change after nutrition education [38]. This indicates that female athletes increased nutritional knowledge, but failed to change their dietary behaviors. This is consistent with a study by Zawilla et al. where they concluded that female athletes may have the nutrition knowledge necessary for correct eating patterns, but choose not to comply with the knowledge they have for other unknown reasons [15]. Abood et al. concluded that to bring about more positive changes in dietary behavior, the nutrition intervention needs to focus on opportunities to practice dietary skills and other barriers to making dietary behavior change may also need to be addressed [38].

Of the 52% of participant's who were able to name two components of the Triad, 51.5% of them did not include EA as one of the components of the Triad. It was the component that was most commonly left out, even though it was the most stressed component in the nutrition education intervention. From this we can conclude that more time needs to be spent focusing on EA and its effect on the Triad when a nutrition intervention is provided.

Collegiate athletes are limited in the time that they have available to spend on their dietary behaviors, which then requires that an intervention be efficient [38]. Barker et al. discussed that nutrition intervention programs should focus on both behavioral and psychosocial changes alongside nutritional awareness [2]. Barker et al. concluded that future research should also focus on measurements to identify problems regarding poor nutritional choices despite adequate nutrition knowledge [2]. Waldroop states that changing the way an athlete thinks about her body, and the way she trains and eats is a challenge [39]; providing nutrition education is likely not enough. Psychological therapy, more specifically cognitive behavior therapy has been shown to be the most effective therapy for EDs and challenges the negative thought patterns about one's self and the world in order to remove the negative, unwanted patterns of behavior [39].

This study has a small sample size, which may have limited results. It would be helpful to educate coaches as well as athletes so that the coaching staff would support the study and their athletes. There is always a risk with self-report dietary recalls that participants will forget some of the items they consumed each d or that they will misrepresent what they actually ate by choosing incorrect serving sizes, etc. The ASA24 dietary recall was time consuming and participants seemed to lose interest the second time they completed their dietary recall. This may be improved by using a simpler method that does not take as long, or if participants could enter foods in real time as they consume them. Other limitations of this study include only using 3 d for the dietary recall, EI days did not line up with EEE measures and this could potentially impact EA measures, as well as the use of accelerometers for exercise EEE due to the risk that a participant may not use it as specified.

Strengths of this study include measured EEE. Body composition measures were completed using a validated method specific to this population. This allowed us to look at the index of EA on an individual level for each participant. We had good compliance from the participants, and were able to work with a population that has a high risk for the Triad while they were in season to get a more accurate view of their EA on a d to d basis while in training and competition.

In conclusion, there is a high prevalence of risk factors in this population of collegiate female athletes. An early prevention of the Triad and an aggressive intervention for those already at risk is necessary. Nutrition education provided in a classroom setting increased nutrition knowledge scores among participants, but did not change dietary behavior. A change in behavior to increase EA is necessary to decrease the risk of short and long term consequences associated with the Triad.

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CHAPTER 3

DEVELOPMENT AND FEASIBILITY OF A MULTIMEDIA DIGITAL DIETARY ASSESSMENT (MDDA) METHOD

Abstract

Obtaining accurate self-reports of energy intake is difficult. The purpose of this study was to develop and evaluate the feasibility of a new multimedia digital dietary assessment method. Using the proposed method, participants recorded the foods they selected and consumed during eating occasions using their own digital video/audio enabled electronic device. A video image and audio description of the foods selected was recorded and subsequently a digital photograph of their plate when they finished eating. Participants uploaded the digital records to a customized website. Thirty six students completed portion size estimation training, and twenty eight students piloted the assessment method for three days. Trained undergraduate dietetic students analyzed the video/audio recordings and digital photographs to estimate energy consumed using the USDA nutrient composition database. Of 407 paired video and photo pairs, a randomized sample of 61 were analyzed by at least two people, each blinded to the estimate of the other. If the two estimates were not within 10% of kilocalories, a third estimate was obtained. The two most similar estimates were used to obtain intra-class correlation coefficients (ICC = 0.89, $p < 0.001$). Students who piloted the method reported that they preferred this method to using a paper-pencil method or weighed food records; however, the uploading procedure was slow and caused frustration. The method provides an

objective assessment of energy intake and with further development may be useful in specific populations such as young-adults who are accustomed to frequent use of personal electronic devices.

Literature Review

Martin and colleagues suggest that the gold standard for energy intake (EI) measurements in free living humans is doubly-labeled water (DLW) [1]. This method provides an accurate measurement of EI, as it measures total energy expenditure (TEE), which is equal to EI when the body is in a state of energy balance [1]. The main limitation to this energy measurement is the restraint of requiring participants to be in energy balance (EB) [1]. A caloric deficit or overconsumption of energy would make this an inadequate measure of EI [1]. In free-living situations this is not a valid measure of EI. Other limitations of the DLW method is the high cost associated with supplying participants with the DLW, and DLW is also not readily available [1]. In addition, the DLW method provides no information about the macronutrient and micronutrient content of the foods eaten by participants [1].

The weighted food record (WFR) is considered the most accurate method for estimating EI [2]. The WFR requires participants to weigh the foods that they consume with a sensitive scale that is accurate to ± 1 gram [3]. Participants then record the weight of the items they are consuming; this eliminates the need for participants to estimate portion sizes [3]. However, pre- and post-weighing of food during observation of participants consuming the food in real time is labor-intensive and burdensome for the participant [2, 4]. This method may cause participants to modify their dietary intake or disrupt their normal eating pattern because they know that someone is measuring their intake and waste [2, 4].

The 24-hour (h) recall is commonly used to estimate EI in individuals because it is a quick method with low cost [4, 5]. 24-h dietary recalls are completed for 3 – 7 days (d)s for an estimate of usual intake; for athletes, a 3-d 24-h recall is considered the criterion standard for assessing an athlete's typical EI [6]. A trained individual is required to interview participants about their food and beverage consumption over the last 24-hs [1]. This method relies on the assumption that the food and beverages consumed in the previous 24-h period is representative of normal EI [1]. 24-h recalls with multiple-pass methods have resulted in a significant underestimation of EI [7]. Strengths of this method include: individuals do not have to be literate, and this method is not burdensome to participants [4]. The accuracy of this dietary measurement relies heavily on the participant's ability to remember what they have consumed throughout the day, as well as participants making food portion estimations [8]. Interviewers also have to be very persistent to obtain all needed dietary information from participants [8]. The main source of error associated with the 24-h recall and other EI methods is the incorrect estimation of portion sizes [4].

Food records are another common dietary self-report method [1]. Participants have to estimate portion sizes of the foods and beverages that they consume, and then record these amounts in a food record [1]. A study comparing EI from food records to DLW found that participants using food records significantly underreported their intake [9]. Another study that provided visual aids in an effort to enhance portion size estimations of food and beverages found that participants still underestimated their intake by > 10% [10]. Food records that have been kept on personal digital devices have not been shown to be more accurate than 24-h recall or traditional pen and paper food records [11, 12]. The source of error here once again is the estimation of portion sizes by participants [13]. Results from these studies have indicated that a method is needed that will not require the participants to estimate portion sizes [11, 12]. Digital methods of dietary analysis may be able to aid in removing the burden from participants estimating portion sizes to trained individuals, in free-living situations [14].

A new approach to dietary assessment involves participants taking photos of food before and after it is consumed [14]. In the lab, Registered Dietitians (RD)s or trained nutritionists estimate the portion sizes of the food and beverages that were consumed [1]. Consumption of food and beverage is then estimated by comparing the photos before and after food consumption [1, 14]. These portion estimations from the RD or nutritionist are then entered into a database or computer application to calculate the composition of food and beverages consumed, including EI [15].

This method has been validated by comparing it to the reference method of WFR [1]. The digital photography method has been found to produce highly reliable results and to be accurate in measuring the EI of adults in a controlled setting [14]. Studies conducted in free-living situations to validate this method of food photography have indicated that this method can be used to assess EI in individuals, and that this method successfully reduces the burden on both the participants and the researchers that are associated with the WFR [1, 16].

In a study by Lazarte, et al. two methods of dietary assessment were used simultaneously, a WFR, and a 24-h recall in combination with a food photo atlas to aid with correct portion size estimations (N = 45) [4]. The photo atlas contained 78 color photographs of foods that were commonly eaten by participants [4]. The photo atlas had pictures of the commonly eaten foods in various portion sizes to assist the interviewer and participants in estimating portion sizes [4].

Lazarte et al. observed that the 24-h recall with digital photographs in combination with the photo atlas provided a good estimation of food portion sizes and resulted in comparable consumed amounts as the WFR [4]. The food atlas minimized errors that might occur with blind portion size estimations, and minimized the burden that is associated with completing a WFR [4]. This study concluded that the 24-h recall with digital photographs combined with a photo atlas was a good alternative to the WFR in regards to estimating EI and nutrient intakes [4]. Other studies using digital photographs that are taken by participants, help estimate plate waste and EI estimates, and aide in reducing under and overestimates of intake in multiple settings [1, 14, 17]. Utilizing trained experts to analyze the amounts of food consumed from digital photographs may minimize the main sources of error that have been associated with EI [18].

Martin et al. developed a Remote Food Photography Method (RFPM) that analyzed food photographs to compute EI. Photographs of foods were captured in free-living conditions with a cell phone that contained a camera. These photographs were then sent to researchers in near real-time. Researchers created a database that contained over 2,100 photographs of different foods and over 250 photos of different portion sizes of each of those foods from previous studies. Each food was then linked to the USDA database for energy and nutrient information. When foods were not found in the database, the manufacturer was contacted, or a website or food label was used for nutrient composition and energy data [1].

The amount of food in each photograph taken by participants was also weighed and recorded. Trained RDs estimated portion sizes of food consumed by comparing the two photographs with photographs from the standard portion database, and without the database. Estimated EI differed significantly when the portion size database was not used, compared to when it was used. This study concluded that RDs can reliably and accurately estimate EI if they have access to photos providing a standardized portion size. The researchers then tested this method in a free-living population. Participants took photographs of all of the food and beverages that they consumed over a 4-day period. The RDs then estimated EI, and recorded problems that they encountered with the pictures that hindered their ability to estimate EI[1].

In the second part of this same study, participants were recruited to participate in the study. Participants (N = 52) participating in the RFPM study were 18-54 years in age with a BMI of 20-35. Participants could not currently be taking any medications that would alter their eating behavior and be in good general health [1]. Participants were divided into two groups; one group consumed and recorded their intake in the laboratory, and one group received a pre-weighed cooler of food which they took home, and then returned with leftovers to the laboratory the following day. This second group was categorized as consuming food and beverages in their natural, free-living environment [1]. Martin et al. reported that the RFPM produced reliable and valid estimates of EI in free-living conditions and in the laboratory setting. The degree of error was very small for the RFPM (-4.7 to -6.6%) which was much lower compared to 37% in other self-report methods. This error was similar between the lab and free-living groups. Participants also rated having high levels of satisfaction in using the RFPM (93.6%) [1].

Martin et al. concluded that this novel method of diet assessment may enhance interventions used to modify diet by allowing clients to send real-time diet information to a specialist without having to visit a clinic [1]. This was a breakthrough in dietary assessment methodology, as the burden of portion estimation was removed from participants and was then estimated and assessed via RDs. This method is expensive, relying on experts to analyze each food photograph, limiting accessibility, and the ability to use this method on a larger scale [19].

The use of crowdsourcing may help to alleviate the drawbacks of using RDs to assess food photographs. Crowdsourcing is relatively new to the area of nutrition. Crowdsourcing relies on a group of "average" people completing a specified task, rather than an expert. Experts in the nutrition arena are scarce and expensive, so the implementation of a group of "average" people completing the same task is a novel idea for providing estimations of EI from digital pictures and audio.

A study by Noronha et al. using PlateMate observed that crowdsourcing was nearly as accurate as a nutrition professional would be in estimating macronutrients and energy content from a digital picture of food [19]. Noronha et al. recruited three professional RDs to estimate portion sizes of 18 photographs showing 36 distinct foods [19]. The portion estimations from the RDs were compared to results from the PlateMate crowdsourcers [19].

This study demonstrated that through careful coordination, untrained crowdsourcers may approach the accuracy of experts in the estimation of nutrition information from photographs of meals [19]. There were some items that the crowdsourcers struggled estimating correctly, namely: beverages and salad dressing, and whether or not they were fat-free, sugar-free, etc. [19]. The undergraduate dietetic students that participated in this study were more informed about nutrition and estimating portion sizes than the “average” person. The objective of this study was to develop and evaluate the feasibility of a new multimedia digital dietary assessment method (MDDA).

Materials and Methods

This study was approved by the Utah State University Institutional Review Board. Participants were informed that their participation was voluntary. A total of 36 undergraduate dietetic students participated in this study. Of the 36 students that participated, 19 students were in an upper level nutrition class and received credit in class for their participation in the study. These students had the opportunity to sign a waiver to opt out of having their information used for the purpose of research (Appendix F). None of the students opted out. These 36 students acted as both client (individual recording information about what they were eating) and nutritionist (estimating portion sizes and analyzing EI). 36 students completed phase I, and 28 students (77.7%) completed phases II and III. Six students (16.7%) completed and returned the qualitative questionnaire.

Phase I: Training (N = 36)

A short demonstration (25 minutes) was provided to students via a PowerPoint presentation to explain the nature of the study and to introduce the estimation of portion sizes via the multi-media digital dietary assessment (MDDA) method (Appendix G). This MDDA method included the use of digital videos and photos of meals and snacks. Each time a participant submitted information on any food consumed, it was termed an eating occasions (EO). The digital recording also included an audio recording of the participant describing details about the foods selected and consumed. Participants were instructed to provide additional details about mixed dished such as salads (i.e., what kind of dressing was on top), or what types of condiments were included on a sandwich.

A "credit card" sized card was included in each digital recording to serve as a reference size. During the training phase, participant nutritionists were provided 14 digital videos of EOs and were asked to estimate the portion sizes of foods consumed and to obtain EI estimations (EIEs) using the USDA nutrient composition database (Appendix H). These 14 EOs had been measured prior to being given to the students, providing a predetermined true amount of energy in each EO to compare to the student's estimations. Students were allowed two weeks to complete this training portion of the study. Students' estimates were to be within 10% of the predetermined true amount of energy for each EO. RDs in the RFPM underestimated calories by 4.7 – 6.6% [1], we wanted to limit our study to a similar degree of error at ≤ 10%. If students were outside of the 10% cutoff for estimated energy per EO, they completed a second short training where they were informed as to whether they over or underestimated portion sizes and energy in the first 14 videos. In this case, they were provided 5 more pre-measured videos of EOs to assess as additional training.

Phase II: Recording Intake via Digital Videos (N = 28)

Participants were instructed on how to be clients, via another short demonstration (10 minutes) via a PowerPoint presentation and demonstration with a digital video enabled cell phone; about how to record EO via an electronic device that has digital video recording capabilities. Participants were instructed to include a “credit card” sized card that was not an actual credit card, in the recording for size reference. Participants were instructed to include specific products in the video that were included in their EO. For example, if a student had a sandwich they made from home, if possible, they would include the specific brand of bread in the background of the video, for example: Sara Lee.

Participants were instructed to pan the digital video from a horizontal view with the “credit card” sized card being held upright for a view of depth of the dish, cup, food items, etc. The participants were to pan over the foods and explain the items in their EO in an audio recording as they recorded the food items. Participants then took a photograph of their plate after they were finished with their EO to assess plate waste, and the amount of food that was actually consumed. Participants were instructed to upload their completed meal recordings and photos to a website that was created by computer scientists Vladimir Kulyukin, and Vikas Reddy, to house the digital videos and photos and also to allow the nutritionists access to the videos and photos to estimate portion sizes and EIEs in the next phase.

Phase III: Analyzing "Real Life" Dietary Videos (N = 28)

Students were then allowed access to register as nutritionists on the website where the uploaded videos were being stored. Students were not allowed to analyze their own video that they recorded and uploaded. The videos were randomized and students were blinded as to who the uploader of the dietary videos was. 28 students completed analysis of the videos using the MDDA method and the nutrient composition data provided by the USDA nutrient composition database. Each video was analyzed at least twice by two different students, blinded to the estimates of the other. If the analysis of energy content of the EOs was not within 10% of total energy of the estimation of the other dietetic student assessing the same meal, the video was analyzed by a third student. A randomized sample of 61 paired videos and plate waste photos out of 407 paired videos and plate waste photos, were analyzed to completion.

Questionnaire (N = 6)

Participants were asked to complete a short questionnaire (10 questions) upon completion of all three phases of the study. There were six questions in the first section of the questionnaire assessing the second phase of the study, in which students recorded their intake for three days using the digital video recorder on their electronic devices. Questions in this section included: preferences of using this system to record intake, as well as things that could be improved in the MDDA method, strengths and limitations of this method, etc.

Four questions were included in the next section of the questionnaire, asking students about their experience in phase III, in which they evaluated the uploaded videos via the MDDA method and the linked USDA nutrient composition database. Questions in this section included: how did this method of evaluating videos of EOs compare to other methods you have used to evaluate your own or a client's EI, preference and usability, etc.

Statistical Analysis

Regarding the training of the dietetic students as nutritionists in phase I, student's EIEs were compared to the pre-determined true energy for each EO to compute a *score* per meal. The score per EO was the ratio of the estimated amount of energy per EO to the true amount of energy per EO. Scores per EO were summed across all fourteen EOs included in the training PowerPoint presentation for a total score for all of the EOs, and then divided by 14 to provide an average measurement across all fourteen EOs. This same method was completed with the five additional videos that were completed by the students who were outside the 10% estimation of energy per meal parameters in phase I. SPSS software (version 22) was used to run the statistics in this study. Intra-class correlation coefficients (ICCs) were used to examine agreement between the twenty eight students who evaluated 61 randomized videos of EO.

Results

Each student's EIE from phase I was compared to the predetermined true amount of energy per EO. Thirty two (89%) students out of the thirty six students were within

10% of the average predetermined true amount of energy for the EOs with their EIEs. Of the four student's EIEs that were outside of the 10% parameters when compared to the average predetermined true amount of energy for the EOs, one student underestimated by 15%, and the other three student's overestimated intake by 11, 12, and 15% respectively. The range of the ratios comparing the average EIEs to average predetermined true amount of energy for the EOs was 0.85 – 1.15. After additional training, all four student's EIEs for the five additional training videos were within 10% of the predetermined true amount of energy.

Of the 36 participants who participated in the portion estimation training, 28 students (77.7%) provided EIEs from the digital videos/audio and paired photographs of 61 EOs. The average EIEs was 383 kilocalories (kcal) with an average range of 35 – 936 kcal over all 61 EOs. Agreement was high among these student nutritionists with an ICC = 0.89 ($p < 0.001$). We observed that there was a lower agreement for EOs that had a single food item, or for EOs that had five or more food items (ICC = 0.78, 0.77, respectively p-value = 0.023, and 0.002, respectively). We observed that the EOs that had two to four food items had the highest agreement with an ICC = 0.95, $p < 0.001$.

Of the six students who completed the optional questionnaire, five students (83.3%) reported that they thought that recording their EO with their cell phone was a convenient and easy method to track their diet. Half (3) of the students reported that they found it somewhat difficult to track their diet via the MDDA method.

Table 3-1: Questionnaire – recording intake (N = 6)

Question	Yes	No
1. Did you feel like recording EO with your cell phone was a convenient and easy method to track your diet?	83.3% (5)	16.7% (1)
2. Did you find it difficult to track your diet via this method?	50% (3)	50% (3)
3. Do you think this is a method that others would like to use to track their diet compared to other methods?	83.3% (5)	16.7% (1)
4. Do you think after participating with our prototype, that there could be a use for recording intake with cell phone digital cameras in the future?	100% (6)	0% (0)

5 of 6 (83.3%) students reported that they thought that this method of tracking their diet would be a method that others would like to use to track their diet. All six students reported there could be a use for recording EI with cell phone cameras in the future. This information can be viewed in Table 3-1. Qualitative responses to the questionnaire portion regarding participant's experience recording their intake are available in Table 3-2. Qualitative responses to the questionnaire portion regarding participant's experience evaluating videos of EOs using the MDDA method are available in Table 3-3.

Discussion

The use of MDDA for the recording and assessment of EOs is a novel form of dietary assessment, similar to the food photographs used to assess diet composition using the RFPM by Martin et al. [1]. The MDDA surpasses the RFPM method by providing participants with the opportunity to pan over the EO for depth, and the ability to have the participant describe what they are eating in an audio recording included in the video.

Table 3-2 Questionnaire – qualitative responses to recording intake

Question			
Why or why not to - Did you feel like recording EO with your cell phone was a convenient and easy method to track your diet?	• Cell phone was convenient way to track my diet because it was always with me (5) • Easy and simple (3)	• making a quick video was much easier than inputting all of my foods in a diet tracker • Don't have to remember a notebook to track diet	• It was frustrating to try and make sure everything I ate and its packaging was in the video • Never knowing if I took the video in an acceptable way,
If answered yes to: Did you find it difficult to track your diet via this method? Why?	• with snacks I would have much rather written it down than taken a video	• It was easy (2) • convenient because I always have my cell phone with me (2)	• Hard remembering to do it with each meal (2)
Why or why not to - Do you think this is a method that others would like to use to track their diet compared to other methods?	• recording what you are eating and then someone else evaluates the recording	• It is way easier than writing everything down (3)	• It's hard to cheat this program.
Why or why not to - Do you think after participating with our prototype, that there could be a use for recording intake with cell phone digital cameras in the future?	• fairly accurate calculation of their daily caloric calculation of their daily caloric intake	• Phone use is so convenient. • Makes calorie counting easy and simple for the general public.	• New, I think it has potential. Especially if there was an app for video upload • quick recordings where ever you are
Strengths of using your cell phone to record your daily intake (combined responses)	• Fast, convenient, thorough (4) • Accurate view of food	• Mobility (2) • Use of technology (1)	• You always have your phone (2)
Limitations of using your cell phone to record your daily intake	• So convenient, can forget to record your intake • poor video recording capabilities on phone	• Pain to upload the videos (2) • Holding the "card" in the videos and trying to record	• Embarrassing to be recording meals in public (2), writing is more discrete •

Table 3-3 Questionnaire – qualitative responses to evaluating videos MDDA method (N = 6)

Question			
How did this method of evaluating videos of EO compare to other methods you have used to evaluate your own or a client's EI?	• USDA database limited in food choices (2) • It was good, if the videos are specific, it can work great	• It is completely different. I've never used anything like this. I liked the video evaluation! • It was different.	• Evaluating the meals was difficult at times. Especially when people went to restaurants. There was no way of accurately figuring out every detail of the meal they ate
What did you like about evaluating EI via the videos?	• Quick and easy to view videos and then calculate energy per meal • I felt that it was a really quick process • Nothing left to clients recall	• It gave a pretty accurate view of what was actually consumed could see all the extra items that might have been missed with a meal written record	• It was slow, but all diet analysis methods are slow (2) • I liked that I could visually see what the person was eating. I feel like that helps increase accuracy (2).
Please provide strengths about evaluating EI via the videos	• Quick and thorough • Allowed evaluators to see each specific brand • It was pretty simple	• Estimate the amount of food that was prepared and eaten • Nothing would be forgotten, it was all on the film	• Accurate, easy to view • visual, someone else is tracking portion sizes (more honest)
Please provide limitations about evaluating EI via the videos	• The USDA search system is limited in food selections (2). • Homemade and restaurant dishes were difficult to evaluate (2)	• Can't ask questions or dig deeper (what kind of milk or was that bread buttered etc.) (2) • Precise portion sizes can be difficult at times (2)	• Could be limiting based upon how the person videoed the meal. If they weren't very thorough then a written record may have been better.

The dietetic students in this study (N = 36) were able to assess EIEs within 10% of the predetermined true amount of energy during a training experience, and nutritionists (N = 28) estimated EI with a high degree of precision when the MDDA was used in phase II (ICC = 0.89, $p < 0.001$). These values are at least as high as the ICC's reported when a digital photography method was used in free living adults [1] and in cafeteria settings by two trained researchers (ICC = 0.61, $p \leq .001$) [20]. This study demonstrated that trained dietetic students as nutritionists can reliably and accurately estimate EI from digital videos/audio and paired photographs of participant's EOs. The ability to assess the depth of dishes and containers via panning over the foods in the EO with digital video recording, and the addition of audio to explain food items in greater detail are benefits that may play a role in the high ICC that was observed for the MDDA method.

The most common dietary assessment tools, the 24-h recall and the use of food records, require participants to estimate portion sizes [1, 4]. The estimation of portion sizes by untrained participants is the main source of error associated with these dietary methods [1, 4]. The use of the MDDA method removes the burden of participants estimating portion sizes and the error that is associated with doing so. Similarly, the WFR removes the responsibility of participants estimating portion sizes, but requires participants to weigh everything that they consume [3]. Weighing foods at each EO can be very time-intensive and burdensome for participants and makes it difficult for participants to eat on the go or eat outside of the home [2, 4]. The MDDA method is very portable, and minimizes the burden of participants estimating portion sizes without an added burden like weighing foods.

The DLW method requires that participants be in EB to accurately assess EI, which is not appropriate for free-living situations where participants may or may not be in EB [1]. The MDDA method does not require participants be in EB to assess EI. Under consumption or overconsumption of energy will be reflected in the EI estimation, and can be assessed without limiting the reliability of the MDDA method.

Regarding the RFPM, there was not any additional information provided about the EO, besides the food photograph. The RFPM was expensive, having RDs estimating portion sizes and also required the use of a portion size database[1]. The use of students as crowdsourcers can minimize these costs, and requires minimal training and does not require the use of a portion size database.

Additionally, the use of cell phones to post videos and photos to social media sites is a very popular practice [21]. In 2005 it was reported that 8-18 year old US youth spend approximately 6.5 h per d on electronic devices [22]. The MDDA method uses a form of technology that is already popular and understood, and directs it to assess EI. This method may be easy for college students and young adults, and even athletes to implement, as it does not require much time to record EOs; college aged students [23] and athletes have limited time [24]. Students reported that this was a useful method of recording EI because they always had their cell phones with them, which made the MDDA an especially convenient method of recording EOs.

Overall, students seemed to like recording their diets via the MDDA method. It may be time consuming to include all of the brands and packaging of the foods that were being consumed in the EO videos, but this allowed a higher degree of accuracy when assessing EI from the EO videos. This method of recording EO may not be the best option for those eating outside of the privacy of their home, as some students (2, 33.3%) reported feeling embarrassed recording their meals with their phones and recording the audio portion of the recording of their meals when they were around their roommates or in public. The MDDA method may also be difficult for evaluators to estimate ingredients in complex dishes. It may be helpful to require that the recipe be included in the video to aid evaluators in correctly assessing nutrient and energy composition of EO.

Other limitations of recording EOs with the MDDA method that participants who completed the questionnaire (N = 6) reported include: difficulty trying to hold the card upright in the video while recording to assess depth of dishes, it was embarrassing to record meals in public and that using the pen and pencil method would be more discrete in this situation (2), it was a pain to upload videos to the website/slow upload time, forgot to record meals, having poor video capabilities on their phone (Table 3-2).

One student suggested that the use of an app to ease the burden of uploading videos would be a useful addition. This would address the main reason that 3 out of 6 students (50%) that completed the questionnaire listed that the MDDA method was difficult to track their diet, because of the time it took to upload the videos to the website (Table 3-1). Students also reported occasionally forgetting to record an EO. It would be helpful to include a text-message reminder or prompt around general meal times, or to allow students to schedule reminders around when they typically eat during the day.

The same participants also listed many strengths of the MDDA method, including: easy uses of technology, mobility, always have your phone with you, fast, convenient and thorough method of recording EI (Table 3-2). All 6 participants completing the questionnaire reported that they thought that there could be a use for recording intake with cell phones using digital video recording capabilities in the future, and 5 of the 6 participants (83.3%) thought that the MDDA method was a method that they believed others would use to track their diet compared to other available dietary assessment tools (Table 3-1).

Limitations reported by participants analyzing the uploaded dietary videos/audio and photo included: the use of the USDA nutrient composition database for the energy content of foods because it was limited in specific food selections and wasn't up to date with recent food manufacturers, complex homemade dishes that did not include a recipe and restaurant dishes were difficult to evaluate, lack of interaction with the video provider did not allow probing questions about types of food eaten (fat free, light or full fat products used, etc.), and poor recording of the meal. Excluding the use of the USDA nutrient composition database, these limitations are similar to the limitations that were observed by Martin et al. with the RFPM [1]. Student nutritionists reported that they preferred the MDDA method of assessing EOs compared to previous experiences with paper-pencil or WFR.

Another barrier to the MDDA method is that students are not always available to provide EIEs. This study provided an opportunity for undergraduate dietetic students to learn about and practice their skills regarding the estimation of portion sizes and assessment of EI. This method may be an option for providing a learning opportunity for dietetic students requiring additional hours to enter a dietetic program or internship.

Strengths of the MDDA method in estimating portion sizes and assessing energy content of EOs were similar to those mentioned regarding the use of the MDDA method for recording the EOs: quick and thorough method of assessing EI, nice to see specific brands of the products being used in the EO, simple, easy to view EOs, accurate assessment of what was being consumed, nothing will be left out or forgotten from the meal due to memory bias, someone else is estimating the portion sizes besides participants. Other comments that participants who completed the questionnaire made about the MDDA method include: "It is completely different, I've never used anything like this. I liked the video evaluation", and "It gave a pretty accurate view of what was actually consumed and you could see all the extra items that might have been missed with a written meal record" (Table 3-3).

The MDDA method shows promise as a dietary assessment method that may be less prone to bias and burden associated with other traditional and commonly used methods. Undergraduate dietetic students were able to accurately estimate portion sizes and EI using a model similar to crowdsourcing. The MDDA method is a novel dietary assessment method that may be a viable option as a dietary assessment method with some changes, including: enhancing the website for faster video uploads or the creation of an app to upload videos to, and the inclusion of recipes in the videos of homemade or complex dishes. With further development, the MDDA method may be useful in specific populations including teenagers or young-adults who are accustomed to frequent use of cell phones and personal electronic devices. The MDDA method provides an objective assessment of EI that removes the burden of estimating portion sizes by the participants, and allows trained dietetic students to assume this burden.

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CHAPTER 4

ECOLOGICAL MOMENTARY INTERVENTION VIA TEXT MESSAGE REMINDERS FOR COLLEGIATE FEMALE ATHLETES AT RISK FOR THE FEMALE ATHLETE TRIAD

Abstract

Female athletes are at an increased risk of developing components of the female athlete triad for many reasons. Development of the female athlete triad is associated with negative consequences to the performance and health of the athlete. An intervention for this population must be brief and able to be incorporated into their daily schedule. Cell phones are common in this population, and offer a viable option for connecting with female student-athletes who are at risk for the female athlete triad. The purpose of this study was to assess the utility of using text message reminders as a way to encourage female athletes at risk for the female athlete triad to consume more calories. A mixed method was used to assess change in energy intake as well as usability of the text reminders. Female athletes viewed a brief educational video about the signs and risks of the female athlete triad. Change in nutrition was examined by assessing baseline information related to the female athlete triad, and change in knowledge upon receiving brief nutrition education related to the female athlete triad. Two different times per day were selected by athletes to receive an ecological momentary intervention via text message reminder for a 2-week period. Dietary energy intake and number of eating occasions were assessed before and during the end of the intervention. Results did not

indicate an improvement in energy intake or eating occasions. Results suggest that text messages may be a beneficial tool for reminding busy female athletes to eat to increase energy intake and decrease risk for the female athlete triad. This method presents challenges and needs to be developed further based on suggestions from athletes to be successful.

Literature Review

Female collegiate athletes are at risk for a condition known as the female athlete Triad (Triad). The Triad is an interrelated spectrum of three components: low energy availability (EA) with or without disordered eating (DE), menstrual dysfunction (MD) and low bone mineral density (BMD) [1]. The Triad is a spectrum of these three interrelated components [2], as female athletes can fall anywhere on a spectrum from optimal EA to low EA, resulting in regular menstruation to amenorrhea, and optimal BMD to low BMD and osteoporosis, respectively [3]. Many female athletes only experience one or two components of the Triad, all three components do not need to present to be at risk of serious consequences of the Triad [3]. The concept of EA follows that as dietary energy is expended in many physiological processes such as: reproduction, thermoregulation, growth and repair of cells and for physical movement; energy expended in one of these processes is then unavailable for others if EA is low [4].

Exercise training increases the amount of energy expended in activity, while endurance sports can even quadruple the amount of energy used in movement and physical activity [4]. The American College of Sports Medicine (ACSM) states that athletes who expend large amounts of energy in prolonged exercise training can become energy deficient without having an ED, DE, or even dietary restriction of any kind which would be called inadvertent low EA [4]. As related to exercise physiology and sports nutrition, EA is defined as dietary energy intake (EI) minus exercise energy expenditure (EEE) [4]. In order to prevent problems from occurring related to the Triad, EA should optimally be maintained at or above 45 kilocalories (kcal)/ kilogram (kg) of fat free mass (FFM)/day (d) to provide adequate energy for all physiological processes [5, 6]. Prolonged low EA can have detrimental effects on health in other areas that will not be discussed in this paper, including endothelial dysfunction and immunity [5].

The ACSM identified three distinct origins of low EA in female student-athletes: obsessive eating disorders (ED), intentional and rational, but mismanaged efforts to lose weight and decrease body size, and finally the inadvertent failure to increase EI to compensate for the high EEE related to training [4]. Female student-athletes may be unaware that they are consuming inadequate energy to support their physical activity [5]. As training levels increase, athletes often fail to increase their EI to match their increased EEE [7]. Athletes receive most of their nutrition knowledge from parents, coaches, and peers [8]. Ironically, athletes identify parents, coaches, and peers as the main source of pressure to be thin [9]. Inaccurate nutrition information that filters to coaches and athletes through the media also exacerbates the challenge for athletes to receive sound sports nutrition education [10].

Providing female athletes with educational information about the importance of proper nutrition is one strategy to prevent low EI, ultimately leading to low EA, however, this prevention strategy has yet to lead to the desired change in behavior [10]. One barrier to increasing EI in female athletes is that the body is not cued biologically to increase EI in response to increased EEE [11]. Additionally, it has been observed in women, that dieting, or limiting EI increased feelings of hunger, but the same loss of energy burned through exercise did not similarly increase feelings of hunger [12]. Borer et al. observed that hunger sensations are triggered by oral and gastrointestinal stimulation, not metabolic mechanisms like EEE [13]. As a result, Loucks states that athletes must eat by discipline, instead of relying on appetite and hunger cues to drive EI [14].

Regardless of the cause of inadequate EI, a number of studies indicate that many female student-athletes fail to meet their required energy demands while training and competing [8, 15-17]. Adequate EI is essential to maintain immune and reproductive function, and to maintain lean tissue and optimal performance [18]. Inadequate EI to maintain these physiological processes operating optimally after energy has been expended in exercise has been termed low EA and is one of the three components of the Triad [19].

Interventions to decrease risk for the Triad

Interventions for the Triad focus on improving low EA, as low EA is the cornerstone of the Triad resulting in the development of the other two interrelated components [20, 21]. Regarding the consumption of adequate EI to provide optimal EA, the attitude of female student-athletes needs to be reformed to see “food as fuel”, not as something that leads to weight gain [5]. In the past, the emphasis for interventions involving the Triad have been based solely on educating female student-athletes about the Triad, with passive learning and minimal participation by those involved [20]. This type of intervention assumed that providing information on the negative effects of consuming inadequate EI would deter these types of behaviors [20]. These education-based interventions had positive effects in increasing participant's nutrition knowledge concerning the etiology and risk factors associated with the Triad, but did not influence participants to increase EI to correct for their low EA [22-25].

Research by Stice and Shaw have indicated that participants have shown decreased DE when participating in more interactive intervention programs [20]. Interventions providing a dietary supplement to increase EI have shown positive results for increasing low EA, leading to the restoration of menses in amenorrheic participants [26, 27]. An intervention has not yet succeeded in positively influencing female student-athletes to improve their EI in free-living situations without providing caloric supplementation [22-27].

Ecological momentary intervention (EMI) is the delivery of an intervention to individuals as they go about their normal everyday life in free-living situations; making this type of intervention ecologically valid as it provides real-time support in the real world [28]. EMIs provide this support for participants in everyday life to aide in practicing new behaviors, and developing new habits, which is ideal for changing dietary behaviors [29]. Using EMIs via mobile phone technology through text messages provides the timing of messages to be specific to when the patients are most in need of support [28].

The use of mobile phone short message service (SMS) text messages as EMI to remind or prompt a behavior change is up and coming, and has shown promise in affecting behavior change in participants in a range of interventions including: smoking cessation [30-32], weight loss [33], treatment of bulimia nervosa [34], diabetes management [35-37], asthma management [38] and to increase adherence to applying sunscreen daily [39], to name a few. Text messaging is very low cost, usually less than $0.01 per message, and is very familiar to most participants [40]. The Pew Research Center released a report that 91% of people in the United States have a mobile device and nearly all of those owning a mobile device have devices that are text messaging-enabled [41]. At the end of 2011, for every 100 people, there were 122 cell phone subscriptions in developed countries [42]. Young adults, aged 18-29 years, send and receive 88 text messages per day on average [42]. SMS text messages are up to 160 characters in length, and are the most widely used data application in the world, with 2.4 billion; double the people that use the internet [43]. Text messages are very convenient for participants because they can be accessed at the time that is personally convenient to them [44].

Cole-Lewis and Kershaw state that text messaging is a suitable intervention for behavior change because it provides a channel for in-the-moment, instant, personally tailored healthy communication and reinforcement that is widely available and inexpensive [45, 46]. Text messages deliver different prevention components based on theoretical models including the health belief model, and the theory of planned behavior [47]. Text messages also include important constructs including cues to action, social support and reinforcement, which are also central to behavioral theories whether or not the researchers intent was to base the content of the messages in theory of behavior change [45]. Text messages used as reminders to provide periodic prompts are an effective method to encourage and also to reinforce healthy behaviors [46]. Interventions using EMIs daily, range from lasting 2-12 weeks, but an ideal duration or frequency for providing EMIs has not been established [28]. A review of SMS text messaging as an intervention described that at least one text message per day may be appropriate to help motivate people to change weight loss behaviors without adding a large burden on them [48]. Heron and Smyth recommend that for behaviors that occur multiple times per day like smoking, several daily EMIs may be required [28].

The success of SMS text messages as an intervention and for preventative behavior modifications [39] may indicate its use in other areas such as athletics. Abood et al. observed that athletes have a finite amount of time in their schedule, requiring an intervention to be efficient, and opportunities to interact formally with athletes may be limited, or not feasible [25]. Text message reminders have not been used with female student-athletes to improve EI, but may be a key route for an intervention program because they require little time and effort from female student-athletes [45]. The purpose of this study was to evaluate the usefulness of a brief EMI via SMS text messages to increase EI/eating occasions (EO) in female athletes at risk for the Triad and to determine the usability/likeability of the EMI.

Materials and Methods

This study was reviewed and approved by the Utah State University (USU) Institutional Review Board. A total of 99 Division I female student-athletes from multiple sports teams at USU consented to participate (Appendix I). This study is a single center, mixed methods study. Female student-athletes from the volleyball, softball, soccer, track and field/cross country teams, as well as the spirit squad (drill team and cheerleaders) were recruited to participate. These sports were recruited because female athletes participating at a high level of competition are at increased risk for the Triad, and those participating in weight sensitive sports with an emphasis on being lean are at a higher risk for the Triad [19, 49, 50]. All participants were invited to complete the screening questionnaire. Only those who screened as at risk for the Triad were invited to participate (69.7%).

Questionnaire

Early detection of athletes at risk for the Triad is imperative to slow, or reverse the progression of more severe consequences of the Triad [51]. The traditional method of assessing risk for the Triad was analyzing EA [6]. EA requires precise measurement of EI, EEE and body composition, measures difficult to obtain in clinical settings without trained researchers [52]. Analyzing EA can be difficult to assess and is not always a feasible option to assess risk for the Triad [52]. Many screening questions have been developed to assess possible risk for the Triad without measuring EA [3, 51].

The Consensus Panel for the 2014 Female Athlete Triad Coalition recommended that female athletes undergo annual screening with the recommended 12-question Triad-specific self-report questionnaire [3, 51]. Of the 12 questions the Coalition recommends as a screening tool for the Triad, eight of the questions are related to DE, one question is related to the risk of bone fractures, and three questions are related to MD [3]. If an athlete is determined to be at risk for the Triad on the basis of a positive response to any of these screening questions, further evaluation of all 3 components of the Triad is warranted [3].

Several exercise-related, psychological and dietary behaviors are associated with increased risk for the Triad, and additional questions regarding risk factors and warning signs of the Triad should also be included for a more comprehensive screening process [3]. These questions focus on 4 categories: athletes at risk for ED, athletes at risk for MD, athletes at risk for stress fractures, and warning signs of the Triad [3]. The Triad has many components involved, requiring additional questions to be included in screening for the triad including whether the athlete is happy with her current weight, as well as about how the athlete feels she is performing [7].

Participants were directed to a website that was constructed for this study, and were prompted to register, where they were asked to provide their year in school, their respective sport, as well as their phone number, email address, and cell phone provider. Participants were asked to complete a questionnaire containing 40 questions related to nutrition and the Triad (Appendix J).

The first 13 questions were Triad screening questions recommended by the Female Athlete Triad Coalition in 2013 and 2014 [3, 51]. The following 11 questions were included from the risk factors and warning signs of the Triad recommended by Javed et al [3]. These combined 24 questions were used as screening questions to assess whether female student-athletes were at risk for the Triad to participate in this study [3].

The remaining 16 questions were added to provide more information about participant's dietary behaviors, knowledge about the Triad, feelings towards approaching coaches and trainers about components related to the Triad, and information regarding sport participation and general nutrition knowledge. This questionnaire was accessed online via a website that was created for this study. Participants were not timed, and completed the questionnaire privately, without any external influences. A list of the questions and answers from the questionnaire are provided in Table 4-1 and Table 4-2.

Triad Video

Participants were directed to view a brief video (9:59 minutes) providing information about the Triad. A Registered Dietitian (RD) introduced the components of the Triad, the risks associated, how to avoid the Triad, and steps to take if a participant thought they might be experiencing some warning signs of the Triad.

Table 4-1: Triad screening questions and answers (N = 99)

	Yes	No
Do you worry about your weight?	54.5%	45.5%
*Do you limit the foods you eat?	51.5%	48.5%
*Do you lose weight to meet requirements for sports?	81.8%	18.2%
*Does your weight affect the way you feel about yourself?	60.6%	39.4%
*Do you feel like you have lost control over what you eat?	12.1%	87.9%
*Do you make yourself vomit or use laxatives or diuretics?	2%	98%
*Have you ever suffered from an ED?	8.1%	91.9%
Do you ever eat in secret?	5.1%	94.9%
#Do you have monthly menstrual cycles?	77.8%	22.2%
*Have you ever had a stress fracture?	25.3%	74.7%
Do you use oral contraceptives?	15.2%	84.8%
Do you feel pressure to be thin from your coach?	2%	28%
Do you feel pressure to be thin from your teammates?	6.1%	93.9%
Do you feel pressure to be thin from your parents?	14.1%	85.9%
Do you feel pressure to be thin from your friends?	6.1%	93.9%
Are you a vegetarian?	3%	97%
Do you have low self-esteem?	19.2%	80.8%
Did you begin sport training at a young age?	80.8%	19.2%
Have you noticed a decline in your performance or energy levels?	37.4%	62.6%
Are you frequently injured or sick?	20.2%	79.8%
*Are you dissatisfied with your appearance?	31.3%	68.7%

*If answered positively, participants were immediately screened into the study
#If answered negatively, participants were immediately screened into the study
Otherwise, answering positively to 3 or more questions screened participants into the study

Table 4-2: Non-screening questions related to the Triad (N = 99)

	Yes	No
Do you feel like you are eating enough to support your training for your sport?	72.7%	27.3%
Have you ever heard of the female athlete triad?	28.3%	71.7%
Can you name the three components of the triad-		
Low energy/DE	19.2%	80.8%
Menstrual Dysfunction/Amenorrhea	12.1%	87.9%
Osteoporosis/low BMD	13.1%	86.9%
Name all three components of the Triad?	8.1%	91.9%
Name only two components of the Triad?	8.1%	91.9%
Name only one component of the Triad?	3%	97%
Does have a low BF% mean that you will perform better in your sport?	37.4%	62.6%
Is it bad to skip your period?	58.6%	41.4%
Do you feel like you can talk to your trainers or coaches about eating or menstrual problems?	71.7%	28.3%
Have you heard teammates talking about missing their period?	50.5%	49.5%
Have you heard teammates talk about dieting?	60.6%	39.4%
Do you eat breakfast?	86.9%	13.1%
Do you ever skip meals because you are busy or because they are too close to practice?	76.8%	23.2%
Do you feel starving when you get home from practice?	67.7%	32.3%
Have you ever had a nutrition class?	49.5%	50.5%%
Would you like to change your diet in any way?	79.8%	20.2%

Triad Risk Assessment

Participants were assessed to be at risk for the Triad, and eligible for participation in this study, if they answered positively to three of the first 24 questions that include the Triad-screening questions suggested by the Female Athlete Triad Coalition [3, 51], and the 11 risk factors and warning signs of the Triad [3], or if they indicated that they experienced less than 9 menstrual cycles in the past 12 months. Female student-athletes were also assessed to be at risk if they answered positively to questions relating directly to the three components of the Triad. The questions that are directly related to the three components of the Triad are highlighted in Table 4-1. Participants answering positively to a question regarding whether or not they have previously suffered from an ED were contacted and referred to a registered dietitian on campus at USU.

Ecological Momentary Intervention

Participants self-selected two of the following times per day that they would like to receive the EMIs in the form of SMS text messages. The time options were from six am to midnight in 15 minute increments. Athletes also had the option of selecting the category of reminder that they would like to receive. The categories of the reminders they could choose from include: before practice, after practice, before weights, after weights, breakfast, lunch, dinner, and a snack. Participants could select two categories of text message reminders to receive at two different times per day. The two times that participants selected to receive text message reminders were the same every day.

Participants received the EMI via text message reminders for 14 days. On day 12 they were prompted to record their second set of three 24-hour dietary recalls while receiving the EMI via text message reminders for the three day period they were recording their diet. Text messages were simple and short, for example, a message that a participant would receive if they had selected the breakfast category would be as follows: Breakfast is important to fuel your day (Appendix K)!

Diet

A diet recall was used to assess EI over three 24-hour (h) periods at baseline, and at the end of the two week EMI using an online program available at https://asa24.nci.nih.gov/ that provides an automated self-administered 24-hour recall

(ASA24) that was developed by the National Cancer Institute (Bethesda, MD, USA). ASA24 is based on the USDA Automated Multiple Pass Method (AMPM), which has been validated to accurately estimate mean total EI in adults and athletes more specifically [53, 54]. Participants were instructed to track their diets on two weekdays, and one weekend day in order to capture their mean "usual" intake [55]. These three 24-h dietary recalls are considered the criterion standard for assessing an athlete's typical EI [56]. Participants also marked the time of day that that they typically ate a meal or snack, termed EOs, pre- and post-intervention to evaluate whether they included additional EOs as a result of the intervention.

Exit Survey

Upon the completion of the final three 24-hour dietary recalls, participants were asked to complete an exit survey regarding their experience receiving the text message reminders, and questions regarding the Triad to assess change in knowledge following the brief video about the Triad (Appendix L). Questions included: Do you feel like the text message reminders were useful in helping you remember to eat, and why do you feel this way? Did you increase the number of meals or snacks that you consumed from receiving the text message reminders, and why or why not?

Participants were also asked to list things they liked and disliked about receiving the reminders, and things that they would like to change about the text message reminders. Participants were also asked if they could name the three components of the Triad, what could be done to prevent the Triad (increase EI) and what the first sign of the Triad was (amenorrhea/lack of menstruation for > 3 months). In the exit survey, participants were asked to list up to two things that they liked and up to two things that they did not like about receiving the text message reminders, as well as up to two things that they would change about the text message reminders.

Statistical Analysis

IBM Statistical Package for the Social Sciences (SPSS), version 22 was used to perform the statistical analysis. Descriptives and frequencies used to assess baseline information. The responses from the qualitative exit survey were coded and grouped based on their similarity into categories, and the main themes were identified. This coding was performed by multiple researchers to assess agreement on themes and confirm which responses were assigned to certain groups. A chi-squared test was performed to assess the percentage of participants who responded a certain way to the questionnaire, and baseline demographics and whether they were at risk or not. A p-value < 0.05 will indicate statistical significance. Fisher's exact test was performed instead of a chi squared test for categories that contained cells with < 5, when you would expect there to be > 5 per cell. ANOVA was used to assess change in EI pre-intervention and at the end of the EMI, as well as to assess change in EO pre and post-EMI. McNemar's test was used to assess change in knowledge related to the components of the Triad.

Results

Quantitative Results

All 99 participants completed the Triad-screening questionnaire. Upon completion of the Triad-screening questionnaire, 69 participants (69.7%) were assessed to be at risk for the Triad. Of the 69 at risk participants, 32 (46.3%) completed the entire study. Participant's baseline information related to the Triad is provided in Table 4-3.

There were no statistically significant differences between respective sports regarding risk for the Triad, listed in Table 4-4. There was a significant difference in risk for the Triad based on year in school ($p = 0.028$). It was observed that risk seemed to increase after freshman year (Table 4-4).

There were also more freshman participating in this study than any other age group, at 36 out of 99 total participants (36.4%), followed by juniors, sophomores, and then seniors (Table 4-5). The number of female student-athletes who reported having experienced a stress fracture presently or in the past was 25 (25.3%).

Table 4-3: Baseline characteristics of participants related to the Triad

(N = 99)	%
Stress Fracture	25.3
Reported ED	8.1
OCT to control MD	15.2
< 9 menstrual cycles per year*	23.5
MD	38.7
Total athletes screened at risk	69.7
Primary Amenorrhea[1]	9.1%

*Not including the OCT controlled menstruation
[1]Delay of initial menstruation until after age 15

Table 4-4: At risk vs. not at risk for the Triad

	N =	At Risk	Not At Risk	p =
Year in School				0.028
Freshman	36	52.7%	47.2%	
Sophomore	24	87.5%	12.5%	
Junior	29	72.4%	27.6%	
Senior	10	80%	20%	
Sport				0.981
Volleyball	8	75%	25%	
Soccer	12	66.6%	33.3%	
Track and Field/XC	46	65.2%	34.7%	
Spirit Squad (Cheer and Dance)	11	72.7%	27.3%	
Softball	22	72.7%	27.3%	

Table 4-5: Participant's year in school and sport[1]

	Volleyball	Soccer	Track/XC	Cheer/Dance	Softball	Total
Freshman	5.6% (2)	5.6% (2)	58.3% (21)	16.7% (6)	13.9% (5)	36.4% (36)
Sophomore	4.2% (1)	25% (6)	45.8% (11)	12.5% (3)	12.5% (3)	24.2% (24)
Junior	17.2% (5)	10.3% (3)	34.5% (10)	3.4% (1)	34.5% (10)	29.3% (29)
Senior	0% (0)	10% (1)	40% (4)	10% (1)	40% (4)	10.1 % (10)

[1] p = 0.79

The prevalence of female student-athletes using OCT to control MD was 15.2% (15), and those who reported experiencing MD was 38.7% (38). Primary amenorrhea was reported by 9 participants (9.1 %). The average age for participant's experiencing their first menstrual period was 13.51 years ± 1.63 years (p = 0.608). The average number of menstrual cycles that participants experienced in the last 12 months was 10.53 ± 3.33 (p = 0.041).

The question pertaining to risk for the Triad that participants answered yes to the most was “Do you lose weight to meet requirements for sports”, where 81 participants (81.8%) answered yes. The second question that participants answered yes to the most was “Did you begin sport training at a young age”, where 80 participants (80.8%) answered yes. Responses to the rest of the Triad-screening questionnaire are listed in Table 4-1 and Table 4-2

Of those who were screened to be at risk for the Triad (N = 69), 65.2% (45) answered that they worried about their weight (p = 0.001). 59.4% (41) reported limiting the foods they ate (p = 0.017). Twenty-nine participants (42%) reported being dissatisfied with their appearance (p = > 0.001) (Table 4-6).

The percentage of at risk participants who responded “no” to the question “is it bad to skip your period”, was 42% (29) (p = 0.579) (Table 4-7), and 18.8% (13) reported that they did not feel like they were eating enough to support their training for their sport (p = 0.032). There was not a significant difference in baseline knowledge regarding the Triad between female student-athletes “at risk” or “not at risk” for the Triad in their ability to name the three components of the Triad (p = 0.382) (Table 4-8).

The mean caloric estimate for the 3-day dietary recalls pre-EMI was 1906.29 kcals ± 563.4 kcals. The mean caloric estimate for the 3-day dietary recalls at the end of the EMI intervention was 1907.19 kcals ± 726.78 kcals. There was not a significant change in calories from the EMI (N = 32, p = 0.237). The mean number of EOs over 3-days pre- and post- EMI was 4.85 ±1.72 and 4.56 ±1.59, respectively (N = 32, p = 0.616).

There was no change in micronutrient intake, reflecting limited change in diet quality pre- post-intervention as well (Table 4-9).

The change in knowledge for the number of components that participants were able to name pre- and post- the presentation of the Triad video was 0.434 ±0.95 to 0.801 ±1.33 ($p = 0.012$) (Table 4-10).

Table 4-6: Individuals who answered “yes” to Triad screening questions

	At Risk (N =69)	Not At Risk (N =30)	P - value
Do you worry about your weight?	65.2%	30%	0.001
Do you limit the foods you eat?	59.4%	33.3%	0.017
Do you lose weight to meet requirements for sports?[1]	20.3%	13.3%	0.573
Does your weight affect the way you feel about yourself?	65.2%	50%	0.154
Do you feel like you have lost control over what you eat?[1]	13%	10%	> 0.99
Do you make yourself vomit or use laxatives or diuretics?[1]	2.9%	0.0%	> 0.99
Have you ever suffered from an ED? [1]	11.6%	0.0%	0.101
Do you ever eat in secret? [1]	5.8%	3.3%	> 0.99
Have you ever had a stress fracture?	36.2%	0.0%	< 0.001
Do you use oral contraceptives? [1]	21.7%	0.0%	0.004
Do you feel pressure to be thin from your coach? [1]	2.9%	0.0%	>0.99
Do you feel pressure to be thin from your teammates? [1]	5.8%	6.7%	>0.99
Do you feel pressure to be thin from your parents? [1]	18.8%	3.3%	0.058
Do you feel pressure to be thin from your friends? [1]	8.7%	0.0%	0.174
Do you have low self-esteem? [1]	27.5%	0.0%	0.001
Did you begin sport training at a young age?	83.8%	76.7%	0.399
Have you noticed a decline in your performance or energy levels?	47.8%	13.3%	0.001
Are you dissatisfied with your appearance?	42%	6.7%	< 0.001

[1] at least 1 cell has expected counts <5, Fisher’s Exact test was used instead of X^2

Table 4-7: Answered "no" to screening questions

Triad Screening Questions	At risk (N = 69)	Not At Risk (N = 30)	P =
Do you have monthly menstrual cycles?	29%	6.7%	0.014
Other Questions			
Do you feel like you are eating enough to support your training for your sport?	18.8%	40%	0.032
Have you ever heard of the female athlete triad?	69.6%	76.7%	0.471
Is it bad to skip your period?	42%	36.6%	0.579
Do you feel like you can talk to your trainers or coaches about eating or menstrual problems?	26.1%	33.3%	0.462
Do you eat breakfast? [1]	14.5%	10%	0.749

[1]at least 1 cell has expected counts <5, Fisher's Exact test was used instead of X^2

Table 4-8: Answered "yes" to non-screening questions related to the Triad

	At Risk (N = 69)	Not At Risk (N = 30)	P =
Name the three components of the triad?			0.382
One component	4.3%	0.0%	
Two components	10.1%	3.3%	
Three components	8.7%	6.7%	
Low Energy/DE[1]	23.2%	10%	0.168
MD/Amenorrhea[1]	13%	10%	> 0.99
Low BMD/Osteoporosis[1]	15.9%	6.7%	0.333
Does having a low BF% mean that you will perform better in your sport?	40.6%	30%	0.317
Have you heard teammates talking about missing their period?	52.2%	46.7%	0.614
Have you heard teammates talk about dieting?	65.2%	50%	0.154
Do you ever skip meals because you are busy or because they are too close to practice?	75%	83.3%	0.362
Do you feel starving when you get home from practice?	69.1%	66.7%	0.810
Have you ever had a nutrition class?	62.3%	56.7%	0.597
Would you like to change your diet in any way?	81.2%	76.7%	0.609
Primary Amenorrhea[1,2]	8.7%	10%	> 0.99

[1] At least 1 cell has expected counts <5, Fisher's Exact test was used instead of X^2
[2] Initial menstruation begins after age 15

Table 4-9: Change in micronutrients pre- and post-intervention

Micronutrient	Pre-Intervention	Post-Intervention	P =
Calcium	1290 ± 1360	1116.9 ±518	0.504
Potassium	2514.7 ± 673.3	2777.7 ± 1189.5	0.225
Zinc	10.59 ± 3.4	18.01 ± 29.5	0.156
Vitamin B6	1.9 ± 0.5	2.55 ± 1.8	0.064
Vitamin B12	4.5 ± 3	5.3 ± 2.6	0.244
Vitamin D	5.0 ± 2.7	5.5 ± 3.6	0.396

Table 4-10: Results of text message intervention (N = 32)

	Pre-Intervention Mean ± Std. Deviation	During Intervention Mean ± Std. Deviation	Degrees of Freedom	P =
Mean calories (3-day) [1]	1906.29 ± 563.4	1907.19 ± 726.78	961	0.237
Mean eating occasions (3-day) [1]	4.85 ± 1.72	4.56 ± 1.59	136	0.616
Name 3 components of Triad [2]	0.434 ± 0.95	0.808 ± 1.33	98	0.012

[1]Analysis of variance was performed
[2]Mcnemar's statistic was used

Table 4-11: Exit Survey Responses (N = 29)

	Yes/Correct	No/Incorrect
Increased eating as a result of receiving messages?	34.5%	65.5%
Useful to receive messages as a reminder to eat?	34.5%	65.5%
Is it bad to miss your period?	51.6%	48.27%
First visible symptom of Triad? (MD)	62.5%	37.9%
Prevent Triad (increase EI)	58.6 %	37.9%

Of those who completed the exit survey (N = 29), 62.5% (18) were able to list the first visible symptom of the Triad (MD), and 58.6% (17) were able to list the component of the Triad that should be changed to prevent the Triad (increase EI). The rest of the exit survey responses may be viewed in Table 4-11.

Qualitative results (N = 27)

The exit survey included open-ended questions; participants were able to provide more than one answer per question. Of the 27 participants who completed the exit survey, 24 participants (88.8%) had a first response to “What did you like about receiving the text message reminders?” and 9 participants had a second response to the question. 58.3% (14) of participants reported that they liked the text messages reminded them to eat, and 11.1% (1) out of the remaining participants reported the same response as the second thing that they liked about receiving the text message reminders. 29.2% (7) of those who completed the exit survey reported they liked that the text message reminders, and that they caused them to think about eating more, and that they were more aware of their diet as a result. 22.2% (2) of the remaining participants reported the same response as what they liked about receiving the messages for their second response. These responses may be viewed in Table 4-12.

Twenty-seven participants had a first response to the question “What did you dislike about receiving the text message reminders?”, and 9 participants had a second response to this question. 40.7% (11) of participants reported disliking that the messages were sent at the same time every day as the first thing that they disliked about receiving the messages. 33.3% (3) of the remaining participants reported that they disliked the same thing about receiving the messages for the second thing that they disliked about receiving the messages (Table 4-13).

Table 4-12: Response to “What did you like about receiving the text message reminders?”

Response Category	% of respondents’ first response (%) (N = 24)	% of respondents’ second response (%) (N = 9)
Reminded me to eat*	58.3%	11.1%
Reminded me to think about eating/more aware*	29.2%	22.2%
Personalized structure: could choose time and category of message*	4.2%	33.3%
Simple/consistent*	4.2%	22.2%
Started packing snacks*	4.2%	11.1%

*some participants listed two answers to this question

Table 4-13: Response to “What did you dislike about receiving the text message reminders?”

Response Category	% of respondents’ first response (N = 27)	% of respondents’ second response (N = 9)
Two messages per day is too often	11.1%	11.1%
Need different times to receive messages depending on the specific day	40.7%	33.3%
Selected the wrong time to receive the messages	7.4%	11.1%
See the message when busy and then forget	3.7%	0%
Messages were unnecessary/Didn’t need the reminder	14.8%	0%
Structure of messages/poor information	11.1%	11.1%
Messages were repetitive/annoying	11.1%	11.1%
Duration of time receiving the messages was too long (2 weeks)	0%	22.2%

22 participants (81.4%) answered the question “What would you like to change about the text message reminders initially, and 10 (45.4%) participants had a second

response to the question. The main changes that participants reported wanting to make to the text message reminders were to receive < 2 messages per day at 27.3% (6), and 10% (1) of participants listed this as their second response to the question. Another response to this question was that they would like the opportunity to change the times of day that they received the messages daily, at 36.4% (8) and 10% (1) for the first response, and for the remaining participant's second response, respectively (Table 4-14).

Table 4-14: Response to "What would you like to change about the text message reminders?"

Response Category	% of respondents' first response (N = 22)	No. of respondents' second response (%) (N = 10)
Receive fewer messages per day (< 2)	27.3%	10%
Change times receiving the messages daily	36.4%	10%
Choose which days to receive the messages	9.1%	20%
Would like more details about WHAT to eat rather than when	13.6%	30%
Motivational messages	9.1%	0%
Simple reminder to eat, not specific to a meal or snack or activity	0%	20%
Sending fewer messages as time goes on (weaning as habit is formed)	0%	10%
Shorter duration receiving messages (< 2 weeks)	4.5%	0%

In response to the question, "Why or why not do you feel like the text message reminders were useful in helping you remember to eat" (N=27), 25.9% (7) responded that the text messages reminded them to eat/made them think about eating, and 37% (10) reported that they didn't need a reminder to eat; they were already in a good habit of eating. 11.1% (3) reported that they were too busy to eat, even with a reminder (Table 4-15). 25 out of 27 participants (92.5%) responded to the question "Why or why not, did you increase the number of meals or snacks that you consumed from receiving the text message reminders?" 44% (11) reported that they did not increase the number of meals or snacks that they consumed from receiving the text message reminders because they believed that they were already in a good habit of eating, or that they already ate enough. 16% (4) reported adding snacks into their day as a result of receiving the messages, and 12% (3) reported that the messages did remind them to eat (Table 4-16).

Table 4-15: Response to "Why or why not do you feel like the text message reminders were useful in helping you remember to eat?"

Response Category	No. of respondents (%) (N = 27)
Reminded me to eat/made me think eating	25.9%
Too busy to eat even with a reminder	11.1%
Don't need a reminder/already in a good eating habit	37.03%
Scheduling times received, different schedule each day	7.4%
Bad timing	7.4%
Annoying	11.1%

*Participants did not always answer all of the exit study questions

Table 4-16: Response to "Why or why not did you increase the number of meals or snacks that you consumed from receiving the text message reminders?

Response category	No. of respondents (%) (N = 25)
Already eat enough/ good habit of eating	44%
Reminded me I needed to eat	12%
Too busy to fit in more meals/snacks, even though it was a good reminder	8%
Added snacks	16%
Receive the text message reminder, and then forget about it	8%
Receiving the text message reminder did not make a difference in my eating pattern	12%

Discussion

The provision of text message reminders as an EMI to increase EI or EO in participants did not result in a significant increase in kcal consumed pre- and at the end of the intervention. The text message reminders and nutrition education did contribute to an increase in knowledge and awareness of the Triad. According to the qualitative information provided by participants in the exit survey, participants reported that the timing of the messages was one of the biggest problems, and that they would prefer the timing of the messages to be specific to each day of the week, and for the messages to be motivational and provide information about WHAT to eat instead of reminding them to eat in general.

Physically active females at all ages and at differing competitive levels are at risk for the Triad, and those participating at a competitive level or in sports with an emphasis on being lean, or thin have an increased risk for the Triad [5]. Of the 99 participants completing the Triad screening questionnaire, 69 (69.7%) participants were screened to be at risk for the Triad. This prevalence of risk for the Triad is consistent with the prevalence of at least one component of the Triad observed in other studies of female athletes; at the high school level, a prevalence of 78% of varsity athletes had at least one component of the Triad [57], and 60% of female triathletes had at least one component of the triad [58]. Beals and Hill observed a slightly lower prevalence in 112 collegiate female athletes, where 52.7% experienced any one component of the Triad [59], and Schtscherbyna et al. also observed a slightly lower prevalence of any one component of the triad in 78 female swimmers with 47.4% [60].

Participants in this study reported prevalence of the individual components of the Triad were within the ranges that have been observed by other researchers for this population. The prevalence of participants reporting a history of stress fracture was 25.3% (25), and MD was 38.7% (38) and 22.2% of participants also reported that they did not have monthly menstrual cycles. Beals and Hill observed a similar prevalence of MD and low BMD in Division II athletes from 7 different sports, with 26% meeting criteria for MD and 10% for low BMD [59]. The incidence of stress fractures in female distance runners and those competing in track and field in three retrospective studies ranged from 8.3% to 52% [61-63]. In general, clinical signs of MD in exercising women range from 1%-61% [64-66], and in a review of 34 studies assessing secondary amenorrhea, the prevalence ranged from 1%-60% [67]. There is also evidence that suggests that approximately 50% of exercising women experience subclinical MD that they are unaware of, because there are no signs of dysfunction until menstruation is affected, suggesting that MD in physically active females is underreported [68]. 41.4% (41) initially reported that it is not bad to skip your period, showing that there is misconception about the importance of menstruation among female athletes. Education should focus more on the possible causes of missed menstrual periods, and the risks associated with amenorrhea and MD.

8.1 % (8) of participants reported a history of ED. This is higher than the prevalence of clinical ED in a study by Beals and Hill, where 2.7% reported a history of ED [59]. Beals and Manore reported a prevalence of 5.6% of participants with a history of ED [19]. Prevalence of clinical ED have been reported to be as high as 48% in a study by Rucinski et al. with competitive female ice skaters [69].

There was a change in Triad knowledge regarding the number of components that participants were able to name pre- and post- watching the brief Triad video. The number of components that participants were able to name before viewing the brief video compared to after watching was 0.434 ±0.95 to 0.808 ±1.33 ($p = 0.012$). Participants that completed the exit survey ($N = 27$) were able to name the first visible sign of the Triad as MD (62.5%) and were also able to name the component that needed to be changed to prevent the Triad (increase EI/low EA) (60.7%) after viewing the video. A brief educational video with fellow athletes and an RD discussing different aspects of the Triad was beneficial in increasing knowledge, and would be a benefit for a prevention method in the collegiate setting because it only requires a short amount of time to be viewed and female athletes can view the video on their own time. The video is relatable because other athletes their age talk about their experiences with the Triad, and many athletes expressed greater interest in learning about the Triad after viewing the video.

Of those participants who completed their three-day 24-h dietary recall ($N = 32$), 56.3% (18) consumed fewer than 2,000 kcals on average. According to the 2014 Female Athlete Triad Coalition, EI should be set at a minimum of 2000 kcal per day, with the goal to increase energy consumption based on specific EEE[51, 70], at 200-600 kcal/day over several months to improve low EA [51]. The mean EI per day in this study was 1906 kcals pre-intervention.

Text messages have worked successfully to influence behavior change in other populations and addressed many of the barriers previously identified, but we did not observe a significant change in EI or EO during the time that participants were receiving the text message EMI. EMI as text messages may not have been successful in increasing

EI or EO in this population, because there are other possible barriers leading to low EA in female student-athletes. There is not a study to date that has been able to increase EI or EO for those at risk for the Triad besides providing a dietary supplement containing carbohydrate and protein [26, 27].

Text messages as an EMI have worked successfully in other settings; Heron and Smyth were the developers of EMI, and completed a review on the positive effect of EMI as an intervention tool for smoking cessation, weight loss, decreasing DE symptoms, management of diabetes, etc. [28]. EMI as an intervention for smoking cessation was tested in participants (N = 1705) in New Zealand. Text messages were tailored to the timing that participants selected for the dates they chose to quit smoking by. Participants received five messages per day for a week before, and then for four weeks after their chosen quit date. Participants receiving the text message EMI were more successful at quitting smoking compared to the controls at six and twelve weeks follow up (28% vs. 13% and 29% vs. 19% respectively) [31]. Obermayer et al. also used text messages as an intervention for the cessation of smoking in college-aged adults [30]. Participants (N = 46) received an increasing number of coping text messages as they approached their smoking quit date [30]. Participants in this study rated the text message intervention as highly acceptable and 34% had quit smoking at 6 weeks [30].

An intervention based on SMS and multimedia message service (MMS: small picture) was used as an intervention for weight loss in a randomized control trial in overweight participants (N = 65). Participants receiving the text messages 2-5 x per day after four months had lost more weight than the comparison group, losing a difference of 1.97 kg (P = 0.02) [33]. Participants also reported that they would recommend this form of EMI for weight loss to their friends and family [33]. Text messages as EMIs are being used in a wider variety of settings, including the use of EMIs to improve the use of sunscreen (N = 70) [39]. Participants in this study by Armstrong et al. received daily text message reminders providing daily weather conditions and a prompt to apply sunscreen [39]. Participants receiving the text message reminders had a mean daily adherence rate of 56.1% compared to 30% in those participants who were not receiving the reminders (P < 0.001) [39]. Armstrong et al. concluded that the use of text messaging may have implications for public health initiatives [39] .

This subset of female student-athletes battles many barriers to increasing their EI [3]. Athletes are often regarded as a special subgroup that leads a physically demanding lifestyle, and who seem to be invincible and are capable of achieving seemingly extraordinary physical and athletic feats [71]. It is hard to determine whether traits and characteristic of athletes, specific to exercise and diet, are progressing towards DE, or are focused commitment to their sport. This can be very difficult to assess, due to their high training demands, performance expectations, as well as high energy requirements [72-74]. Athletes are perfectionists by nature, especially in sports where female athletes are only competitive for a number of years or who have limited eligibility based on age (such as gymnastics) or scholarship [75]. Following a strict diet, or limiting EI to reach a certain weight to presumably increase performance is worth the risks for a certain time period to some athletes [75]. This makes it difficult to recommend that an athlete gain weight, or increase their EI without a true understanding of the Triad and the long term risks, as well as emphasizing that there is not an ideal body weight or BF for enhanced performance, which needs to be the goal before nutrition education can successfully be provided [75].

Even when female athletes understand proper eating behaviors, their desire to improve their appearance and performance has been observed to be more important than their dietary decisions [76]. Competitive female athletes have many characteristics that are similar to those with EDs: they will work tirelessly to try and achieve an unrealistic or unachievable body shape, have a weight preoccupation, can impose rigid dieting, are very tough minded, have high levels of self-control, and desire to please coach, parents, etc. [77]. It is these same traits that lead to successful athletic performance, but they make it difficult to identify and treat those athletes with ED [77]. These traits are valued in the athletic realm, and can easily be misperceived by medical personnel and the athlete as assets to sport, rather than symptoms [77].

Female athletes are also extremely busy, and may find it hard to fit in times to eat around school and intense practices and competitions [78]. Busy schedules, increased stress, disinterest in food, placing eating as a lower priority, large amounts of time spent traveling may also contribute to decreased EI, as well as participating in eccentric eating habits, like eating the same thing on a daily basis, or certain meals as part of the pregame routine [79]. Initially, 79.8% or participants answered that they would like to change their diet in some way. Female athletes may also be very strict or habitual in their eating habits; many reported in this study that they did not need the text message reminder, that they were already in a good habit of eating, and did not want to change their eating routine (11 of 25 completing the exit study, 44%). 76.8% (76) of participants reported skipping meals because they were too busy to eat, or because meals were too close to practice, and 67.7% (67) reported returning home starving after completing practice/training.

We did not see a significant increase in EI and EO from the intervention; a focus may need to be made on correcting other behaviors related to DE in female athletes besides the busy schedule and the assumption that most female athletes don't realize they are in a state of low EA. One of the main problems with regards to DE is body dissatisfaction [79]. There are many misperceptions about body size and body competition in the sporting world [80]. Weight awareness is an increasing problem in young female athletes, with an increase in incorrect self-weight perception and added societal pressures to be thin in our modern society [81, 82]. 37.4% (37) of participants responded that they believed that having a lower BF percentage would lead to improvement in their sport. 60.6% (60) of participants reported that their weight affects the way they feel about themselves, and 81.8% (81) reported that they lose weight to meet requirements for their sport.

In this study, there was a combined percentage of 28.3 % of participants who felt pressure to be thin from: coaches (2%), teammates (6.1%), parents (14.1%), and friends (6.1%). Most coaches unknowingly increase the risk of the Triad in athletes as they praise weight loss, and believe that there is an ideal body type for sport and performance, and that once an athlete has stopped menstruating, they have reached their ideal body weight and body composition [75]. Female athletes may also hide their DE or knowledge of their amenorrhea or MD due to fear of backlash from coaches, or the possibility of missing competitions or as a sign of weakness [83]. If the female athlete is seeking a lower body weight as a way to improve performance or to please a coach or parent, this desire may overrule the health consequences of the Triad to the female athlete [84]. Coaches, parents, friends and teammates may be putting pressure on female athletes to look a certain way, and in their limited amount of time and resources these female athletes are trying to achieve just that [7].

Of the 99 participants who completed the Triad screening questionnaire, 41.4% (41) participants reported that they did not think it was detrimental to skip their period. For those female athletes who do not believe that it was negative to miss menstrual cycles, information about the long term effects of amenorrhea, and the resulting low BMD and other risk factors may be beneficial to include in an intervention. Risks of the Triad, and the intervention may need to be converted into the athlete's "language " [85], and be explained in terms of decreased athletic performance, musculoskeletal injuries and stress fractures [86], with food being referred to as "fuel," and that it is essential for optimal performance [5]. Athletes should be informed that seeking help with DE or other components of the Triad is not a form of weakness, but a strength, as they work to improve health and performance [3].

Participants reported that they would have preferred self-selecting the times that they would receive the text message reminders specific to each day, as their academic and practice schedule changed day to day. Because of their ever-changing schedule as student-athletes, the text message reminders they received at the time they selected were not applicable on some days when their schedule was different. A method of tailoring EMI to be more effective involves the delivery of the intervention at a specific time when individuals select that they need support [28]. Tailored, self-selected times daily would be a useful option for tailoring the text message EMI for this population.

Participants also requested that they receive the text message intervention for less than 2 weeks, stating that “two weeks was too long to receive the texts. After a week I got used to receiving them and began to ignore the messages.” Participants would also prefer more information in the text message reminders regarding WHAT to eat, along with the reminder of when to eat. Participants also suggested that the messages be more motivational, and inspiring, so they would be motivated to make better food choices throughout the day.

Many participants reported that they did not like using the ASA24 program to track their diets. They reported that it was too time consuming, and that it was hard to enter foods that they prepared at home. It would be beneficial to use another food tracking program that was more user friendly and was able to accommodate home prepared meals. The ASA24 program is also limited to the ability of participants to recall what they have consumed during the day. There may be a bias associated with reporting diet to over or underestimate calories consumed.

Nutrition education should be provided with an emphasis on increasing EA, and the concept that food is fuel for training and recovery, instead of focusing on body weight [7]. If the female athlete can recognize that her current dietary behavior is detrimental to her future goals and physical performance, she may be ready to discuss and learn about how to change her behavior [7].

One limitation of this study was the number of participants that completed the entire study. It was very difficult to retain participants in this study. Female student-athletes cannot be compensated, or provided an incentive to participate in research due to the National Collegiate Athletic Association (NCAA) rules. It would have been beneficial to have the athletes sign up for the text message reminders and record their first day of dietary information when they met to begin the study. We believe that there would have been a higher level of participation if more had been accomplished in that first meeting, instead of relying on the female athletes to sign up for the reminders and track their diet on their own, after being prompted, without a walkthrough of the program. We did not use EA to assess prevalence of the Triad, but a simpler method using a Triad-screening questionnaire to avoid adding stress to the athletes' busy schedule.

Strengths of this study include the high number of participants who completed the initial questionnaire, the use of ASA24 for the three-day dietary recall, as it was a multiple pass method that provided us with detailed results regarding each athlete's EI. This study was a mixed method study, which added power to our quantitative results, as athletes were able to explain why they did or did not do something, and what they did and did not like about receiving the EMI. This allows us the opportunity to improve the EMI in the areas suggested by athletes, to work towards a more successful intervention for female student-athletes in the future.

An EMI text messaging intervention that taught female athletes about the Triad and provided text message reminders about consuming kcal at times selected by the participants was successful in increasing the participants' knowledge of the Triad, but not in increasing the amount of calories consumed. Participants reported that they would like the ability to select the time that they would receive the text message reminder each day specifically, and that they would like to receive the messages for less than two weeks. Participants would also like more information regarding things that would be beneficial for them to eat with the reminder, as well as a motivational tone to the reminders. SMS text messages as an EMI is still a viable option for this population after some changes to the messages, and times that athletes receive the messages are changed.

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CHAPTER 5

GENERAL DISCUSSION

This document provides a review and evaluation of the female athlete triad (Triad), barriers for female athletes related to the Triad, and interventions aimed to increase energy intake (EI) to lower the risk for the Triad. In two of the studies discussed in this document, it was discovered that there was a high prevalence of risk for the Triad in female collegiate athletes at USU. Increasing EI to subsequently increase energy availability (EA) was targeted as the main intervention to decrease risk for the Triad in female athletes.

The review in Chapter 1 provided information regarding interventions used previously to decrease risk for the Triad. Interventions providing nutrition education were successful at increasing nutrition knowledge, but unsuccessful at changing dietary behaviors of female athletes to increase EI/EA [1-4]. The only successful interventions thus far have provided female athletes dietary supplements to increase EI/EA [5-7].

Two interventions were implemented at USU with female athletes to increase EI/EA: the provision of nutrition education and the use of text message reminders as an ecological momentary intervention. An increase in nutrition knowledge was observed from both interventions, but neither intervention was successful in increasing EI/EA. We gained important feedback from both interventions, providing guidance for future research and development of more successful interventions regarding the Triad.

A problem with addressing risk for the Triad is the difficulty regarding dietary tracking methods for busy female athletes [4]. The usual dietary tracking methods typically place a burden on student athletes by requiring a substantial time commitment or by having athletes estimate portion sizes, or rely on their memory to recall what they have consumed throughout the day [8-10]. Placing the burden of estimating portion sizes on the female athlete opens the door for error in obtaining an accurate view of their actual EI, which then reflects directly on an inaccurate view of their EA, and risk for the Triad [10].

A new dietary tracking method was created and piloted to possibly remove the burden of portion size estimation from female athletes; requiring minimal time and effort to track daily EI. Participants that piloted this new dietary tracking method reported high rates of acceptability and usability.

Nutrition Education Intervention

At the time that the nutrition education intervention was implemented in Chapter 2, there were only a few known studies regarding the use of nutrition education to decrease the risk for the Triad. The question was raised regarding the possibility of implementing a unique spin on the presentation of the nutrition information regarding the Triad, to increase knowledge regarding the triad, and also to stimulate a dietary behavior change to increase EI/EA.

The unique problems that female athletes face regarding the triad include pressure to be thin and lean from their external sources, including teammates [11-14]. With the previously conducted intervention studies in mind, and understanding some of the barriers female athletes face in regards to increasing EI/EA, it was important to include two athletes from the women's track and field program at USU, who were also undergraduate dietetic students to help present the nutrition education regarding the Triad to the women's track and field team in Chapter 2. By having fellow athletes and teammates present the Triad nutrition information, we hoped to lessen the pressure to be thin, and adjust the social norm that is accepted in the sporting world around an ideal body shape or weight [11-13], and the belief that missing menstrual periods means you have successfully reached the ideal body weight [15]. We were successful in increasing knowledge regarding sports nutrition and the Triad, but as the other nutrition education interventions also observed, we were unable to affect dietary behavior of having female athlete's increase EI/EA; even with the unique spin on the presentation of information regarding the Triad.

One of the difficulties we had in this study was the lack of research based dietary tracking methods that would provide daily EI in kilocalories (kcal) to researchers. ASA24 provides a comprehensive view of female athletes EI, but was not a preferred method of dietary tracking by the participants. Participants reported that using ASA24 took a lot of their limited and valuable time. To address this difficulty with a dietary tracking method that would require a limited amount of time, and also provide EI to researchers, we developed a new method of dietary tracking in Chapter 3.

Novel Dietary Tracking Method

This method was created using the qualitative information that was provided in Chapter 2 regarding the amount of time that it took to complete dietary recalls using ASA24. This method is similar to the Remote Food Photography Method (RFPM) created by Martin et al. that uses food photographs to analyze dietary composition of EOs [16]. The MDDA method differs from the RFPM in that participants record video with audio to record their EO instead of photographs, and trained dietetic students analyze the recorded dietary information rather than untrained crowdsourcers [16]. The MDDA method required little time to record dietary information with a video enabled electronic device, most often a cell phone, and removed the burden of the participant estimating portion sizes or assessing the EI of their eating occasions (EO). Videos were uploaded to a website where trained undergraduate dietetic students could then estimate portion sizes and assess EI from the uploaded EOs.

We found that most participants liked this novel method of recording intake, but there were some frustrations regarding the upload time of videos to the website. Participants also reported some discomfort in describing their meals to record the audio portion when roommates were around or when they ate in public. It would be helpful to have an application that participants could download and have housed on their electronic device that would allow for automatic upload of the dietary videos as soon as the recording was complete. This application could also include an option to write what was consumed in a text box to be included with the video instead of the audio to be more discrete for situations where recording audio would be inappropriate or uncomfortable. Development of software that could use other items in the video for reference would also eliminate the need for the reference card in the recording process.

Participants liked that this MDDA method required little time to use, and that they were able to record audio with the video to further describe the things they were consuming, as well as the option of including the packaging and brands of items consumed in the EO. Some participants reported that the MDDA method was so easy to use that they often forgot to record their meals. It would be beneficial to include a reminder or prompt for participants to remember to record their EO.

Participants acting as nutritionists were able to estimate portion sizes and assess EI with a high degree of precision from the uploaded dietary videos with audio. Participants reported that this method was a great use of technology, and was easy to use because participants always had their cell phones with them and were already accustomed to uploading pictures and videos to social media sites. The impact of this study was the creation of a new dietary tracking method that uses modern technology and allows for quick recording of dietary information that is assessed by trained individuals to remove the burden of estimating portion sizes and analyzing EI from the layperson for greater accuracy in assessing EI [8].

Ecological Momentary Intervention

(Text Message Reminders)

Text messages as an ecological momentary intervention (EMI) have been successful at influencing behavior change in other settings, including: smoking cessation [17-19], weight loss [20], and increased adherence to daily sunscreen application [21] to name a few, because they provide in-the-moment, instant communication and reinforcement [22, 23]. Because of the success of EMIs using text messages in other studies to influence behavior change, and the lack of interventions that had successfully influenced behavior change to increase EI/EA in female athletes at risk for the Triad without providing dietary supplementation [1-4], an intervention was created using an EMI providing text message reminders to female athletes at risk for the Triad.

Again, we did not see a significant increase in EI/EA as a result of this intervention. Some participants did report that they remembered to eat more, or pack a snack as a result of receiving the reminders. Participants provided qualitative feedback for enhancements of this intervention. The main feedback that we received was that participants would like to be able to change the times that they received the messages each day, and that they would like to receive the messages for less time (< 2 weeks). Participants also reported that they would like messages to be more motivational, and to provide more information on WHAT to eat, instead of just a reminder to eat.

This was a novel intervention aimed at increasing EI/EA in female athletes at risk for the Triad, seeking to implement an EMI that has been successful in influencing behavior change in other situations. If improved upon, this type of intervention using an EMI for female athletes at risk for the Triad may be successful at influencing behavior changes to influence EA/EI. The Triad presents serious consequences for those who do not make changes to increase EI/EA [24, 25], it is important to continue working towards a successful intervention to achieve this.

Future Directions

An intervention for female athletes at risk for the Triad that does not provide a dietary supplement to increase EI is still needed desperately to decrease risk for the Triad before serious consequences result from prolonged low EA in female athletes. An intervention aimed at changing dietary behavior to increase EI/EA needs to include more than nutrition education to be influential. Using tailored text messages that provide motivational messages for athletes to remember to eat, as well as including examples of things female athletes could consume may aid in influencing athlete's behavior to increase EI/EA. A pilot study with female athletes about specific EOs that they would like to receive messages about, and more feedback and guidance regarding how text messages could be improved would be beneficial. It would also be helpful if participants could respond to the text message reminders with questions, or suggestions on specific aspects of the messages that would be more beneficial to them, and tailor the messages accordingly.

It may be beneficial to address the social norms in athletics regarding the acceptance of amenorrhea, the pressures that athletes feel to be thin and lean, and the idea of an ideal body shape or size for sport. This may be approached by recruiting teammates to help teach their fellow teammates about these misperceptions, and providing someone female athletes can approach with questions or concerns regarding the Triad. Changing the dietary behaviors of female athletes at risk for the Triad may require a two pronged approach: addressing their busy schedule by reminding them to eat via text message reminders, and changing their view regarding the barriers to overcoming the Triad.

There are many barriers facing female athletes making it difficult to reduce their risk for the Triad. One of these barriers is the lack of time female athletes have to focus on eating and the importance of maintaining adequate EI. This may be addressed by providing more tailored text message reminders. A second barrier is the culture surrounding female athletes to be thin and lean, and the misperceptions that female athletes have about missing their period, and the unattainable goal of achieving an ideal body shape or weight for appearance or increased physical performance. This may be addressed by including teammates in the teaching process, to change the social norms of being physically active for female athletes.

Conclusion

In Chapter 1, the literature supplied information regarding the Triad is a problem in female athletes [26-29], and that interventions providing dietary supplements were the only successful interventions that have improved EI/EA [5-7]. Our research confirms that the Triad is a common problem among female athletes. Two interventions that were implemented with female athletes at USU were successful in increasing nutrition knowledge regarding the Triad, but unsuccessful at changing dietary behavior to increase EI/EA. Many other studies have been successful at increasing nutrition knowledge regarding the Triad; however, changing dietary behaviors in female athletes is difficult to accomplish [1-4].

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APPENDICES

Appendix A: Copyright Release

04/01/16

Dear Dr. Heidi Wengreen,

I am in the process of preparing my dissertation in the Nutrition and Food Science department at Utah State University. I hope to complete my degree program in May, 2016.

I am requesting your permission to include the attached material as shown. I will include acknowledgments and/or appropriate citations to your work as shown and copyright and reprint rights information in a special appendix. The bibliographic citation will appear at the end of the manuscript as shown. Please advise me of any changes you require.

Please indicate your approval of this request by signing in the space provided, attaching any other form or instruction necessary to confirm permission. If you charge a reprint fee for use of your material, please indicate that as well. If you have any questions, please call me at the number below.

I hope you will be able to reply immediately. If you are not the copyright holder, please forward my request to the appropriate person or institution.

Thank you for you cooperation,

Jennifer Day
801-628-6923

I hereby give permission to Jennifer Day to reprint the following material in her dissertation.

Day J, Wengreen H, Brown KN, Heath E (2015) "Prevalence of Low Energy Availability in Collegiate Female Runners and Implementation of Nutrition Education Intervention." Sports Nutr Ther 1.101: 2.

Fee: none

Signed: Heidi Wengreen

Appendix B: Consent form to participate

USU IRB Approval: Jan. 15, 2013
Approval Terminates: 01/14/2014
Protocol 4881
IRB Password Protected per IRB Administrator

Department of NDFS
8700 Old Main Hill
Logan UT 84322-8700
Telephone: (435) 797-2102

INFORMED CONSENT

Food, Fitness, and Performance: A Study of Female Collegiate Runners

Purpose Dr. Heidi Wengreen and master's degree candidate Jennifer Day in the Department of Nutrition, Dietetics and Food Science at Utah State University is conducting a research study to find out more about energy intake and energy expenditure as related to the female athlete triad in female collegiate runners. You have been asked to take part because you are a female runner on the USU track team. There will be approximately 35 total participants in this research.

Procedures If you agree to participate in this research study, you will be asked to:

- Complete two separate 3-day diet analyses using on online program. This will take about 20 minutes to complete each day. You will do this on your own time, not during practice time.
- Wear a small device that will measure your physical activity while you are awake for two days.
- Have your body composition assessed using a BODPOD measure. To use this machine you will need to sit in a small chamber in tight fighting close.
- Attend nutrition education workshops once a week for 6 weeks. Each workshop will take about 20 minutes.
- Complete two questionnaires. These will take about 10 minutes to complete.

New Findings During the course of this research study, you will be informed of any significant new findings (either good or bad), changes in the procedures, risks or benefits resulting from participation in the research, or new alternatives to participation that might cause you to change your mind about continuing in the study. If necessary, your consent to continue participating in this study will be obtained again.

Risks There is minimal risk in participating in this study. However, there is a small risk for loss of confidentiality, but we will take steps to reduce this. You may feel psychological discomfort from revealing information about eating, exercise and other health behaviors. We will be sensitive to the information you provide but let the researchers know if you have concerns or problems about the program.

Benefits You will be given a report that estimates your energy needs, energy intake, and body composition. This information may help you to plan a diet that may improve your performance and health.

Explanation & offer to answer questions Jennifer Day has explained this research study to you and answered your questions. If you have other questions or research-related problems, you may contact Dr. Heidi Wengreen at (435) 797-1806.

Voluntary nature of participation and right to withdraw without consequence Participation in research is entirely voluntary. You may refuse to participate or withdraw from this study at any time without consequence or loss of benefits. You may be withdrawn from this study without your consent by the investigator, if you miss more than 3 nutrition classes or if you do not complete any of the procedures listed above under "Procedures."

Confidentiality Research records will be kept confidential, consistent with federal and state regulations. Only the investigators, Jen Day and Dr. Heidi Wengreen, will have access to the data collected as part of this study which will be kept in a locked file cabinet or on a password protected computer in a locked room to maintain confidentiality. To protect your privacy, personal, identifiable information will be removed from study documents and replaced with a study identifier. Identifying information will be stored separately from the data and will be kept in a locked file cabinet in a locked room. De-identified data will be kept indefinitely. The study identifier will be kept for one year and then destroyed.

IRB Approval Statement The Institutional Review Board for the protection of human participants at Utah State University has approved this research study. If you have any questions or concerns about your rights or a research-related injury and would like to contact someone other than the research team, you may contact the IRB Administrator at (435) 797-0567 or email irb@usu.edu to obtain information or to offer input.

Investigator Statement "I certify that the research study has been explained to the individual, by me or my research staff, and that the individual understands the nature and purpose, the possible risks and benefits associated with taking part in this research study. Any questions that have been raised have been answered."

Heidi Wengreen, Principal Investigator
435-797-1806; Heidi.wengreen@usu.edu

Jennifer Day, Student Researcher
435-797-7641; jen.day@aggiemail.usu.edu

Signature of Participant By signing below, I agree to participate.

____________________________ ____________________________

Participant's signature Date

Appendix C: Triad Questionnaire

ID__________________________ Date___________________

Pre-Season Nutrition, Health and Athletic Performance Questionnaire

You may use either a pen or a pencil to complete the survey. Please be sure to mark your answers correctly as shown and dark enough that the scanner can read them.

Answer Selection: Correct = ● Incorrect = ☒ ✓ ⊖

1. Have you ever heard of the Female Athlete Triad?

O Yes
O No

2. Please list the three conditions that are included in the Female Athlete Triad.

1.___________________
2.___________________
3.___________________
O I have no idea

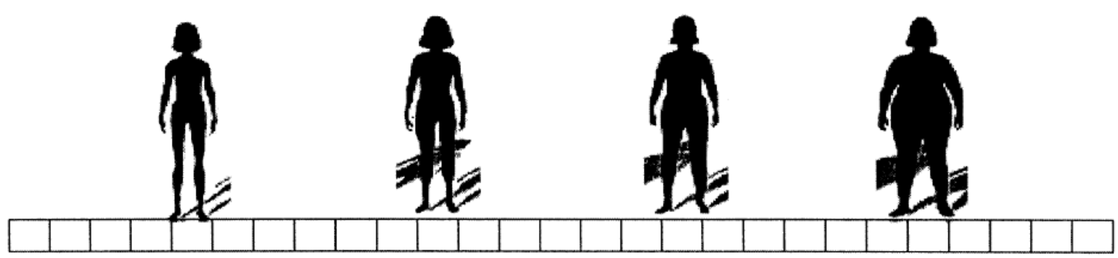
7. Height

________Feet
________Inches

8. Current body weight in pounds. (If you are unsure, give your best estimate)

_________pounds

9. Place an "X" in the box which best reflects your current appearance.



10. Have you experienced any stress fractures since the track season began?

O Yes
O No

11. Have you made any changes to your food intake or physical activity over the course of the season?

O Yes
O No

12. If you answered yes to 11, please describe those changes

____

13. When do females build the most bone?

____

____

O 0-6 years
O 7-12 years
O 13-18 years

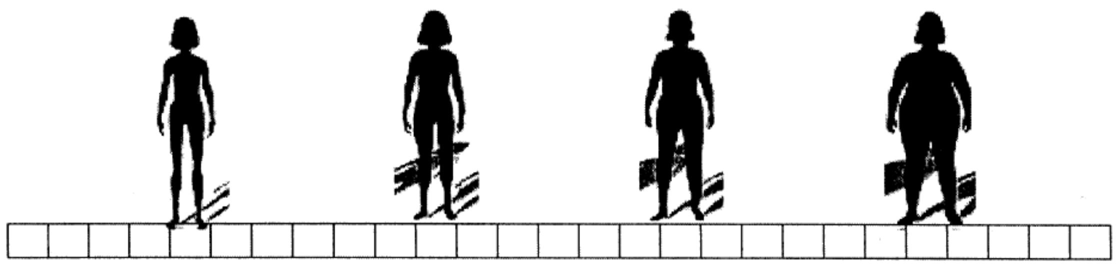
14. What do you think is your ideal weight (what would you like your weight to be?

_______________ pounds

15. Do you think you eat enough calories?

O Yes
O No

16. Place and "X" in the box that reflects the appearance you would most like to look like.



16. Do you feel pressure to achieve or maintain a certain body weight?

O Yes
O No

17. If you answered yes to 9, where does that pressure come from? (select all that apply)

O Myself
O Coach
O Peers
O Parents
O Society/media

	True	False	Don't know
18. Protein is the main energy source for the muscle.	O	O	O
19. Skipping my period makes my bones weak	O	O	O
20. Stress fractures (very small bone cracks or breaks) occur more often in girls that skip their period	O	O	O
21. Carbohydrates should make up at least 50% of total calories.	O	O	O
22. Not eating enough could cause me to lose my period	O	O	O
23. Teenagers with weaker bones will always have weaker bones	O	O	O
24. When exercising in a hot environment and sweating a lot, Gatorade helps your body rehydrate better than water	O	O	O
25. I'm not old enough to have weak bones	O	O	O
26. Vitamins are a good source of energy	O	O	O
27. Skipping my period is my body's way of saying I'm training too hard	O	O	O
28. Milk products are the only source of calcium in the diet.	O	O	O
29. How much I eat does not affect my bone health.	O	O	O
30. Including protein and carbohydrates in my post-workout snack helps me recover faster	O	O	O
31. I feel that skipping my period while playing sports is normal	O	O	O
32. Exercising/Training too much could cause me to lose my period	O	O	O
33. There is room for all foods in the diet	O	O	O
34. Each athlete has a set body fat percentage they should aim for to maximize their athletic performance.	O	O	O

Appendix D: Example of a script for a Triad nutrition education intervention

Session 2: The Female Athlete Triad

Female Athlete Triad- Athlete Testimonial, Brittany Fisher (10 minutes)

- *To help us see the importance of keeping our energy availability up, let's take a look at a video interview of Brittany Fisher, a track athlete at Utah State University. She is going to talk to us about her experience with energy availability, and she will also introduce some topics related to the female athlete triad, which we will be discussing next.*

Show the video clip by Brittany Fisher.

What are your thoughts about this video? Did you notice what she said about energy availability?

Listen to their responses, and guide a discussion about her experience and how it relates to energy availability and nutrition. Use the video to transition into the female athlete triad discussion.

The Female Athlete Triad (10 minutes)

- *One of the main goals of the program is to help increase knowledge of the female athlete triad, and to teach you how evaluate your habits and make changes that promote improvement in overall health and athletic performance.*
- *This is important for each of you as athletes, because the female athlete triad is most common among the athletic population, and can have a significant impact on both health and performance.*

Have any of your heard of the female athlete triad?

If so, do you know the three components of the triad?

- *I am going to go through a few different diagrams representing the female athlete triad.*
-

The three components involved in the Triad are energy availability, bone health (BMD), and menstrual period function. A menstrual period simply refers to the period women have every month. When you have adequate energy available, you are more likely to have normal menstrual periods, and healthy bones.

each of these components are affected in the female athlete triad. The Triad refers to a state of low energy availability, as we talked about last week. It also includes low bone mineral density, such as in osteoporosis, and menstrual dysfunction, which would be skipping or losing your period, or not having a normal period about every 28 days. We will discuss this component more today. Next week we will look in to bone health in depth.

Slide 3: *This slide shows a more detailed diagram of the female athlete triad. You can see the three components as we discussed before. Notice that the top triangle shows a healthy inter-relation between energy availability, menstrual function, and bone health. The bottom triangle shows the other extreme: low energy availability, menstrual dysfunction, and osteoporosis. However this diagram shows not only the two extreme ends of the spectrum, but also shows that not every athlete will be on one end or the other, and may fall in between somewhere.*

Each of the components of the Triad will be discussed extensively throughout this program.

Can someone explain why learning about the Triad would be beneficial for athletes?

For ideas, remind them of the video clip where Brittany discusses her experience with the Triad as a college athlete.

What do you think the take home message would be for the female athlete triad section?

Take Home Message: The female athlete triad includes three components- low energy availability, menstrual dysfunction, and low bone mineral density.

<u>Menstrual Function</u>

Does anyone here actually keep track of their period? (such as writing it down on a calendar or in a notebook?)

- *A normal period would be having a period about every 28 days, or within the range of about 21-35 days. An irregular period means that you only have a period every 35 or more days. It can also refer to only having 4-9 periods per year instead of the normal 12.*
- *Amenorrhea, which is one of the components of the female athlete triad on the disease end, is the absence of a period. There are two kinds of amenorrhea- primary and secondary.*
    - *Primary- a delay in the age you have your first period. This would refer to not having your first period until age 15 or later.*
    - *Secondary- this is the absence of a menstrual cycle for more than three months*

Why might amenorrhea, or not having a period, be a problem?

If they have a hard time with this question, use these to help get them thinking:

- *Not having a period may sound like a great thing… you don't have to deal with that every month, right? Even though this may not seem like too bad of a deal, there are some problems that can come up if you are not having a regular period.*
    - *Infertility is a common problem, and can make it difficult to become pregnant later in life.*
    - *Bone loss can be another problem, and we will talk about this more in the next session.*

- *After you start having a period, it is fairly common to skip a period or not have a menstrual period every 28 days during the first couple of years. For most women, their period is fairly regular after that.*
- *It is important to monitor this because not having a period can have negative effects on your bones. Not having a period changes the hormone levels in your body, which results in weakened bones. This increases your risk for stress fractures (that could negatively impact your athletic performance) and can increase your risk for breaking bones when you are older.*
- *Sometimes female athletes lose their period when they are training. For most girls, not having a period for more than 3 months is NOT normal and it is NOT healthy.*
- *Many factors contribute to menstrual regularity. If you ever go more than 3 months without a period, take a look at how much you are eating in comparison to how much you exercise.*
    - *Do you have low Energy Availability?*
    - *Evaluate whether you eat 3 meals a day, and if you have meals as snacks as necessary.*
    - *If your menstrual cycle does not return you should discuss this with your doctor.*

For the menstrual function section, what is the take home message you learned?

Take Home Message: It is important to have a regular period about every 28 days. Low energy availability can lead to lost or skipped periods, and both low energy availability and loss of a menstrual cycle can contribute to weakening of the bones.

Athlete Testimonial Video- Jessie Chugg

Now that we have discussed these components of the female athlete triad, let's take a look at a video of a female athlete in college that experienced the female athlete triad. Notice the aspects of the Triad that she discusses, including menstrual dysfunction when she lost her period and how it affected her performance.

Show the video clip by Jessie Chugg.

What are the consequences on health and performance that Jessie mentions when she talks about losing her period?

What would the take home message be for this athlete's testimonial about the Triad?

Take Home Message: Though some irregularity with your period is common, it is not normal or healthy to stop having a period during sports participation.

Appendix E: Example of PowerPoint for Triad nutrition education intervention

Slide 1

Female Athlete Triad

USU TRACK

Slide 2

Video Clip

- Brittany Fisher was a distance runner for USU a few years ago.
- This is a clip about her experience with energy availability and the female athlete triad.

Slide 3

Female Athlete Triad

- One of the main goals of this program is to help increase knowledge about the female athlete triad.
- Important for you as athletes because
  - the triad is the most common among the female running population
  - can have a significant impact on bone health and performance
- Have any of you heard of the female athlete triad?
- If you have, what are the three components of the triad?

Slide 4

3 Components

- Energy availability
  - Energy left over after exercise
- Bone health
- Menstrual period function
  - When you have adequate energy you are more likely to have normal menstrual periods and healthy bones

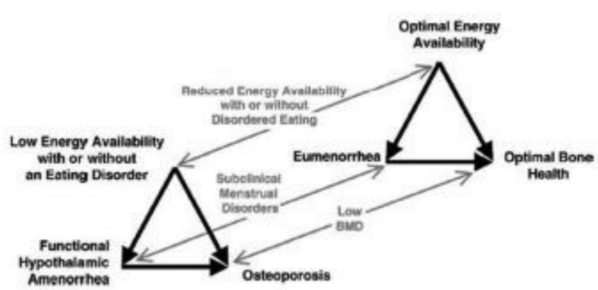
Slide 5

Triad

- Each of these components is involved in the female athlete triad.
- Triad refers to a state of LOW energy availability, which we talked about last week.
- Also includes low bone mineral density.
  - like osteoporosis.
- And menstrual dysfunction.
  - Skipping or losing your period, or not having a normal period about every 28 days.
  - Going to talk more about this today, and focus on bone health.

Slide 6

Spectrum of the Female Athlete Triad



Slide 7

Questions

- Can someone explain why learning about the Triad would be beneficial for athletes?
  - Remind Brittany's video clip
- What do you think the take home message would be for the female athlete triad?
- What are the three components?
- What is the cause?

Slide 8

Menstrual Cycles

- Does anyone actually keep track of their period?
  - Writing it on a calendar or journal?
- Normal Period: having a period about every 28 days or within 21-35 days.
  - Irregular period: have a period every 35 or more days
- Amenorrhea: (one of the components of the Triad) absence of a period.
  - Two kinds of amenorrhea- primary and secondary
    - Primary – a delay in the age you have your first period.
    - Secondary – absence of a menstrual cycle for more than three months

Slide 9

- Why might amenorrhea, or not having a period be a problem?
  – May sound like a great thing… you don't have to deal with it every month, but…

Slide 10

Problems

- **Infertility** is a common problem, and can make it difficult to become pregnant later in life.
  – Good thing is, it is fully reversible once you correct for the low energy availability
- **Bone loss** is another problem
  – We will talk about this next week

Slide 11

Menstrual Cycles

- Common to skip a period, or not have a menstrual period every 28 days during first couple of years after you start having a period.
- For most women, it is fairly regular after that.
- Important to monitor your cycle
  - Missing a period changes hormone levels resulting in weakened bones.
  - Increases your risk for stress fractures
  - Increases your risk for breaking bones when you are older

Slide 12

Menstrual Cycles

- Sometimes female athletes lose their period when they are training. For most girls, not having a period for more than 3 months is NOT normal and it is NOT healthy.
  - Evaluate whether you eat 3 meals a day, and if you have meals as snacks as necessary.
  - If your menstrual cycle does not return you should discuss this with your doctor.

Slide 13

What should I remember?

- For the menstrual function discussion, what is the take home message?

Slide 14

Take Home Message

- It is important to have a regular period about every 28 days. Low energy availability can lead to lost or skipped periods, and both low energy availability and loss of a menstrual cycle can contribute to weakening of the bones.

Slide 15

Video Clip

- Now that we have discussed these components of the female athlete triad, let's take a look at a video of a female athlete in college that experienced the female athlete triad.
- Notice the aspects of the Triad that she discusses, including menstrual dysfunction when she lost her period and how it affected her performance.

Slide 16

Video Clip

- What are the consequences on health and performance that Jessie mentions when she talks about losing her period?
- What would the take home message be for this athlete's testimonial about the triad?

Slide 17

Goals

- Now that we have had two sessions of instruction, this is a good time to set some goals.
- We will be setting two goals today- one related to nutrition, and the other for any health-related behavior.
- It is important to set SMART goals.
- What are the components of a SMART goal?

Slide 18

Goals

- Please take a minute and write your goals down.
- When everyone has finished we will share our goals.

Appendix F: Informed consent to decline participation

UtahState University
Department of NDFS
8700 Old Main Hill
Logan UT 84322-8700
Telephone: (435) 797-2102

Page 1 of 2
USU IRB Certified Exempt: 02/03/2015
Exempt Certification Expires: 02/02/2018
Protocol Number: 6371
IRB Password Protected per IRB Coordinator

Letter of Information

Assessment of PNUTS (Persuasive Nutrition System): a pilot study

Purpose Dr. Heidi Wengreen and PhD candidate Jennifer Day in the Department of Nutrition, Dietetics and Food Science at Utah State University is conducting a research study to find out more about what students eat to estimate energy intake by assessing digital pictures and audio recordings of food and beverages.

Procedures This is a class activity. You are expected to complete the activities listed below, but you have the right to decline the use of your data for research purposes.

- *Receive training on estimating portion sizes in an in-class activity*
- *Record your diet for 3 days using a smart phone device to take digital videos of your food and beverages as well as audio recordings describing details in the meal that cannot be assumed from the videos alone.*
- *Estimate food and beverages consumed for 3 days using the USDA database*
- *Complete a questionnaire to assess usability of the smart phone application and provide insight on your experience in the study and any improvements that can be made to the application*

New Findings During the course of this research study, you will be informed of any significant new findings (either good or bad), changes in the procedures, risks or benefits resulting from participation in the research, or new alternatives to participation that might cause you to change your mind about continuing in the study. If necessary, your consent to continue participating in this study will be obtained again.

Risks There is minimal risk in participating in this study. However, there is a small risk for loss of confidentiality, but we will take steps to reduce this by assigning a study ID and removing any personal identifiers. You may feel psychological discomfort from revealing information about eating. We will be sensitive to the information you provide, but let the researchers know if you have concerns or problems about the program.

Benefits You will be given a report that estimates your energy intake. You will also gain experience in estimating portion sizes and using ASA24 software to estimate energy intake.

Explanation & offer to answer questions Jennifer Day has explained this research study to you and answered your questions. If you have other questions or research-related problems, you may contact Dr. Heidi Wengreen at (435) 797-1806.

Voluntary nature of participation and right to withdraw without consequence
Participation in research is entirely voluntary. You may refuse to participate or withdraw from this study at any time without consequence or loss of benefits. If you decline to have your information included in this research study, your grade in the class will not be affected. **If you choose to opt out of having your information used in this study, please sign the decline to participate section at the end of this letter.**

Confidentiality Research records will be kept confidential, consistent with federal and state regulations. Only the investigators, Jen Day and Dr. Heidi Wengreen, will have access to the data collected as part of this study which will be kept in a locked file cabinet or on a password protected computer in a locked room to maintain confidentiality. To protect your privacy, personal, identifiable information will be removed from study documents and replaced with a study identifier. Identifying information will be stored separately from the data and will be kept in a locked file cabinet in a locked room. De-identified data will be kept indefinitely. The study identifier will be kept for one year and then destroyed.

IRB Approval Statement The Institutional Review Board for the protection of human participants at Utah State University has approved this research study. If you have any questions or concerns about your rights or a research-related injury and would like to contact someone other than the research team, you may contact the IRB Administrator at (435) 797-0567 or email irb@usu.edu to obtain information or to offer input.

Investigator Statement "I certify that the research study has been explained to the individual, by me or my research staff, and that the individual understands the nature and purpose, the possible risks and benefits associated with taking part in this research study. Any questions that have been raised have been answered."

Heidi Wengreen, Principal Investigator 435-797-1806; Heidi.wengreen@usu.edu	Jennifer Day, Student Researcher 435-797-7641; jen.day@aggiemail.usu.edu

Decline Participation
By signing below, I am declining the use of my information for this research study.

____________________________ ____________________________
Declining participant's signature Date

____
Participant's Name (PLEASE PRINT)

Appendix G: Training PowerPoint slides for estimating portion sizes

Slide 1

Training

Estimating portion sizes from Diet Videos

Slide 2

Every meal will have a "credit card" sized card in it for reference

Salad is one item that always looks like more than what is really there

1 cup ½ cup

Slide 3

The smallest amount is ¼ cup.
Each serving of fruit increases by a ¼ cup.
The ½ cup amount is pretty close to the same size as the "card"

Slide 4

When possible, count items instead of estimating in cups

- 6 carrots
- 5 blackberries
- 4 broccoli florets

Slide 5

When in doubt, do the item with salt, or with fat unless the item is described to be without

- Little detail provided for a food item, use most simple description in USDA

- Go to the manufacturer’s website if you are given enough detail

Slide 6

MEAL 1

Please try to analyze on your own before moving on to the next slide

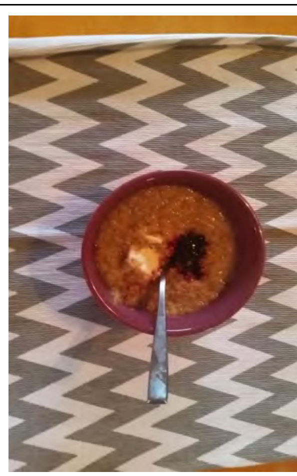
Slide 7

Example of item estimates for MEAL 1

Food Item	Estimated amount	Food Code (USDA)	Calories
Bran Flakes	3/4 cup	08029	98
Quaker Oats, Dry	1/8 cup	08402	37
PB smooth style	1 T	Adam's PB www.adamspeanutbutter.com/product	105
Nonfat milk	1/2cup	42290	43
Raisins, Seedless	1/16 cup (1 T)	09298	31
			Total Calories: 305

Slide 8

MEAL 2



- Quaker steel cut oatmeal
- *Franklin Greek cream cheese

Appendix H: Form to complete training videos of 14 EOs

<u>Training Assignment: Estimating Calories from Diet Videos</u>

Meal #1

Food Item	Estimated amount	Food Code (USDA)	Calories
			Total Calories:

Meal #2

Food Item	Estimated amount	Food Code (USDA)	Calories
			Total Calories:

Appendix I: Informed consent

Utah State University
Department of NDFS
8700 Old Main Hill
Logan UT 84322-8700
Telephone: (435) 797-2102

Full AAHRPP Accreditation

Page 1 of 2
IRB Approval Date: 11/2/2015
IRB Approval Expires: 11/1/2016
Protocol #6906
IRB Password Protected per IRB Director

INFORMED CONSENT
Female Athlete Triad

Purpose Dr. Heidi Wengreen and PhD degree candidate Jennifer Day in the Department of Nutrition, Dietetics and Food Science at Utah State University are conducting a research study to find out more about nutrition and health in female collegiate athletes. You have been asked to take part because you are at least 18 years of age, are a female athlete attending USU, and competing in track and field, cross-country, soccer, volleyball, softball, dance team or cheerleading. Approximately 130 female athletes will be invited to participate in this research.

Procedures If you agree to participate in this research study, you will be asked to:

- Provide your cell phone number to researchers so that you may receive two text message reminders per day for two weeks.
- Complete one questionnaire about your behaviors related to eating and exercise. This will take about 20 minutes to complete.
- If, based on your responses, you are at risk of developing a common condition among female athletes, you may be invited to continue in the study and engage in the procedures that follow.
    - Watch a 10 minute video about how nutrition impacts female athletes.
    - Record your diet for three days using ASA24 online dietary tracking program
    - Choose two times per day to receive a text message reminder
        - You will receive two text messages a day at a time that is self-selected for two weeks. Not all who are invited to participate will receive text messages during this two week period.
    - Finally, you will be asked to complete a brief online exit survey regarding your experience in the study. This should take you about 5 minutes to complete.

Risks There is minimal risk in participating in this study. However, there is a small risk for loss of confidentiality, but we will take steps to reduce this. You may feel psychological discomfort from revealing information about your eating.

Benefits You may learn more about your risk for a common condition among female athletes. You may learn more about how to properly fuel your body to maintain health and optimize performance.

Explanation & offer to answer questions Jennifer Day has explained this research study to you and answered your questions. If you have other questions or research-related problems, you may contact Dr. Heidi Wengreen at (435) 797-1806.

Voluntary nature of participation and right to withdraw without consequence Participation in research is entirely voluntary. You may refuse to participate or withdraw from this study at any time without consequence or loss of benefits. You may be withdrawn from this study without your consent by the investigator if you do not complete the procedures listed above under "Procedures."

Confidentiality Research records will be kept confidential, consistent with federal and state regulations. Only the investigators, Jen Day and Dr. Heidi Wengreen, will have access to the data collected as part of this study which will be kept in a locked file cabinet or on a password protected computer in a locked room to maintain confidentiality. To protect your privacy, personal, identifiable information will be removed from study documents and replaced with a study identifier. Identifying information, including cell phone numbers and email addresses collected from you if you are selected for the text message group, will be stored separately from the data and will be kept in a locked file cabinet in a locked room.

IRB Approval Statement The Institutional Review Board for the protection of human participants at Utah State University has approved this research study. If you have any questions or concerns about your rights or a research-related injury and would like to contact someone other than the research team, you may contact the IRB Director at (435) 797-0567 or email irb@usu.edu to obtain information or to offer input.

Copy of consent You have been given two copies of this Informed Consent. Please sign both copies and keep one copy for your files.

Investigator Statement "I certify that the research study has been explained to the individual, by me or my research staff, and that the individual understands the nature and purpose, the possible risks and benefits associated with taking part in this research study. Any questions that have been raised have been answered."

Heidi Wengreen, Principal Investigator	Jennifer Day, Student Researcher
435-797-1806; Heidi.wengreen@usu.edu	435-797-7641; jen.day@aggiemail.usu.edu

Signature of Participant By selecting "I Agree" (online), I am at least 18 years of age and agree to participate.

If you are not 18 years of age or older, you will not be able to participate in this study.

Appendix J: Triad Screening Questionnaire

1. Do you worry about your weight?
2. Do you limit the foods you eat?
3. Do you lose weight to meet image requirements for sports?
4. Does your weight affect the way you feel about yourself?
5. Do you feel you have lost control over what you eat?
6. Do you make yourself vomit or use laxatives or diuretics?
7. Have you ever suffered from an eating disorder?
8. Do you ever eat in secret?
9. How old were you when you had your first menstrual period?
10. Do you have monthly menstrual cycles?
11. How many menstrual cycles have you had in the past 12 months?
12. Have you ever had a stress fracture?
13. Do you use oral contraceptives?
14. Do you feel pressure to be thin from your coach?
15. Do you feel pressure to be thin from fellow teammates?
16. Do you feel pressure to be thin from your parents?
17. Do you feel pressure to be thin from friends?
18. Are you a vegetarian?
19. Do you have a low self-esteem?
20. Did you begin sport training at a young age?
21. Have you noticed a decline in your performance or energy levels?
22. Are you frequently injured or sick?
23. Are you dissatisfied with your appearance? How so?
24. Do you feel like you are eating enough to support your training for your sport?
25. If no to the question above, why are you not eating enough?
26. Have you ever heard of the Female Athlete Triad?
27. Can you name the three components of the Female Athlete Triad (name as many as you can)
28. Does having a low body fat percentage mean that you will perform better in your sport?
29. Is it bad to skip your period? Why or why not?
30. Do you feel like you can talk to your trainers or coaches about eating or menstrual problems?
31. Have you heard teammates talk about missing their period?
32. Have you heard teammates talk about dieting?
33. What is something that you would like to learn about nutrition in regard to your sport?
34. Which sport do you participate in?
35. How many hours per week do you typically practice?
36. Do you eat breakfast?

37. Do you ever skip meals because you are busy or because they are too close to practice?
38. Do you feel starving when you get home from practice?
39. Have you ever had a nutrition class?
40. Would you like to change your diet in any way? If yes, how?

Appendix K: Text message reminder categories and message

Before practice
(name), grab a snack to fuel up for practice!
After practice
(name), eat a snack to refuel after practice!
Before weights
(name), fuel up for weights with a snack!
After weights,
(name), refuel after weights with a snack!
Breakfast
(name), breakfast is important to fuel your day!
Lunch
(name), lunch is important to fuel your day!
Dinner
(name), dinner is important to refuel from your day!

Appendix L: Exit Survey

Name the 3 components of the triad
-
-
-

What can you do to prevent the Triad?
-

What is usually the first sign of the Triad?
-

Do you feel like the text message reminders were useful in helping you remember to eat?

Yes?

No?

Why do you feel this way?

Did you increase the numbers of meals or snacks that you consumed from receiving the text message reminders?

Yes?

No?

If no, why not?

What did you like about receiving the text message reminders?
-
-

What did you not like about the text message reminders?
-
-

What would you like to change about the text message reminders?
-

Would you be interested in meeting to talk more about nutrition?

CURRICULUM VITAE

JENNIFER DAY

1537 E 2100 N Logan UT 84341

Education

BACHELORS OF SCIENCE | MAY, 2010 | UTAH STATE UNIVERSITY

· Major: Dietetics

· Graduated with honors

ACCREDITED INTERNSHIP | MAY 2011 | UTAH STATE UNIVERSITY

· Emphasis in food service management

· Registered Dietitian

  · Registration number: 1039422

  · State of Utah License number (Certified Dietitian): 8187291-4902

PHD CANDIDATE | UTAH STATE UNIVERSITY, 3.84 GPA

· Emphasis in sports nutrition with a focus on the female athlete triad

· Dissertation: "Identifying and Reducing Risk of the Female Athlete Triad in Division I Athletes"

· Multi-disciplinary project with the computer science department, nutrition department, and athletic department

· Developed curriculum about the female athlete triad and its components for female athletes at USU

· Developed a new, convenient method of recording daily dietary intake using an electronic device that has video recording capabilities that is submitted online to be assessed.

    · Aimed at improving dietary assessments for busy athletes

· Anticipated graduation date is May, 2016

Experience

SELF-EMPLOYED BUSINESS OWNER | DAY FARMS | JULY 2005-CURRENT (SEASONAL)

· Picked, purchased and transported produce to local farmers markets and roadside stands to provide fresh produce to the public

- Supervised 3-4 employees
- Maintained the inventory and quality of produce to ensure there was always product available to the public
- Worked closely with employees and with the public to resolve problems and to provide the best customer service possible

STUDENT ATHLETE – TRACK AND FIELD | UTAH STATE UNIVERSITY | 2005-2010

- Developed relationship with Greg Gensel and the Track and Field coaching staff, as well as the strength and conditioning coaches, athletic trainers, physical therapists and team doctor
- Observed the flow and processes of the athletic department and the importance of communication within different disciplines in athletics
- Helped extensively with recruits to help them see the benefits of attending Utah State University
- Served as a team captain in 2010, worked closely with track and field athletes as a mentor and to help resolve problems

HEAD TEACHING ASSISTANT | NUTRITION DEPARTMENT – UTAH STATE UNIVERSITY | AUG 2012 - CURRENT

- Managed 2-4 teaching assistants
- Worked closely with professors in the nutrition department to ensure that proper grading was completed in a timely manner
- Worked with students to resolve problems and to answer any questions that they might have regarding nutrition assignments

INDEPENDENT NUTRITION CONSULTANT | JULY 2013 - CURRENT

- Developed and implemented a sports nutrition program assessing nutritional status, providing nutrition education and medical nutrition therapy for high school athletes who were interested in sports nutrition or who were at risk for disordered eating and the female athlete triad, as well as other specialized conditions including gluten intolerance, anemia and multiple food allergies
- Provided nutrition counseling, on correct methods to adjust the diet of clients to a healthy and correct portion size as well as personal training (NASM) to aid in healthy weight loss, and muscle gain

NUTRITION CONSULTANT | BECK WESTERN BROKERAGE | JUNE 2015 - CURRENT

- Answered questions about efficacy and usefulness of nutraceutical ingredients and food stuffs

INSTRUCTOR | UTAH STATE UNIVERSITY | JANUARY 2016 - CURRENT

- Instructed 105 undergraduate students about nutrition
  - Macronutrients/micronutrients, food safety, weight management, etc.
- Managed the online portion of this hybrid class

GUEST LECTURER

- Presented information on proper fueling, nutrient timing, and the female athlete triad to female high school athletes at Layton High School
- Presented on the female athlete triad and the importance of proper fueling to track athletes at Mountain Crest High School
- Presented on proper fueling for collegiate athletes, nutrient timing, food preparation and planning ahead for meals in mandatory weekly class for student athletes at Utah State University
- Presented on proper sports nutrition, including fueling and nutrient timing for collegiate athletes as well as on the female athlete triad to athletic trainers in a sports medicine class at Utah State University
- Presented on common food and diet misperceptions that the general public clings to and how to dispel this misinformation to dietetic students in a class at Utah State University
- Presented on the female athlete triad and proper ways to estimate portion sizes and analyze diets via pictures and videos to dietetic students in a class at Utah State University
- Presented on the female athlete triad, caffeine and sugar intake in teens, and general healthy eating to high school teachers at the Family and Consumer Science Conference
- Presented a poster at the Food and Nutrition Conference and Expo in Atlanta, Georgia on the prevalence of the female athlete triad among female collegiate track and field runners at Utah State University
- Presented on the female athlete triad, risks and prevention to an undergraduate sports nutrition class at Utah State University
- Participated on a panel instructing students about graduate school and pursuing a degree with an emphasis in sports nutrition at Utah State University

Published Works

Day, Jennifer. "Evaluation and Validation of BODPOD Body Scan Method as Compared to DEXA, Effect of Calcium and Caloric Intake in Female Collegiate Track Athletes." (2010). http://digitalcommons.usu.edu/cgi/viewcontent.cgi?article=1042&context=honors

V. Kulyukin, V. Reddy Sudini, H. Wengreen, J. Day. "A Cloud-Based Infrastructure for Caloric Intake Estimation from Pre-Meal Videos and Post-Meal Waste Pictures." In Ed. H. R. Arabnia, L. Deligiannidis. *Proceedings of the 19th International Conference on Image Processing, Computer Vision, & Pattern Recognition* (HIMS 2015), pp. 161-166, July 27-30, 2015, Las Vegas, NV, USA, CSREA Press, ISBN: 1-60132-404-9.

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Day, J., et al. "Prevalence of Low Energy Availability in Collegiate Female Runners and Implementation of Nutrition Education Intervention." *Sports Nutr Ther* 1.101 (2015): 2.

References

Heidi Wengreen – Associate Professor in Nutrition and Food Sciences at USU – 435-797-1806

Janet Anderson – Professional Practice Professor in Dietetics and Vice Provost at USU – 435-770-5557

Pam Tsakalos - Davis School District's director of nutrition services - 801-402-7650