



Ecological Momentary Intervention via Text Message Reminders for Collegiate Female Athletes at Risk for the Female Athlete Triad

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Abstract

Female athletes are at an increased risk of developing the female athlete triad, which is associated with negative consequences to the performance and health of the athlete. An intervention for this population must be brief and easily incorporated into their daily schedule. Cell phones offer a viable option for connecting with female 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 increase their energy intake. Female athletes viewed a brief educational video about the signs and risks of the female athlete triad. Change in nutrition was examined by assessing knowledge from a questionnaire before and after receiving brief nutrition education related to the female athlete triad. Athletes selected times to receive an ecological momentary intervention via text message reminder for a 2-week period. Energy intake was assessed before and during the intervention using a 3-day dietary recall. The intervention did not significantly increase energy intake. Text messages may be a beneficial tool for reminding busy female athletes to eat in an effort to increase energy intake and decrease risk for the female athlete triad. This method presents challenges and needs to be developed further based on suggestion from athletes to be successful.

Keywords

Female athlete triad, Energy availability, Intervention, Text message, Ecological momentary intervention, Sports nutrition

Introduction

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 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 [2]. Exercise training increases the amount of energy expended in activity, while endurance sports can even quadruple the amount of energy expended by the body [2].

In order to prevent the three components of the Triad from occurring, EA should optimally be maintained at or above 45 kilocalories (kcal)/kilogram of fat free mass/

day to provide adequate energy for all physiological processes [3,4]. Providing female athletes with educational information about the importance of proper nutrition is one strategy that has been used to prevent Low Energy Intake (EI), however, this prevention strategy has not led to the desired change in behavior [5]. One barrier to increasing EI in female athletes is that the body is not cued biologically to increase EI in response to increased Exercise Energy Expenditure (EEE) [6].

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Additionally, it has been observed that when women limit EI by decreasing the amount of calories that they consume, they experienced increased feelings of hunger. When these same women lost the same amount of calories through exercise as was limited through the diet in the first example their feelings of hunger did not increase, even though there was the same deficit of calories in both situations [7].

Borer, et al. observed that hunger sensations are triggered by oral and gastrointestinal stimulation, not metabolic mechanisms like EEE [8]. As a result, Loucks states that athletes must eat by discipline, instead of relying on appetite and hunger cues to drive EI [9]. Regardless of the cause of inadequate EI, a number of studies indicate that many female athletes fail to meet their required energy demands while training and competing [10-13].

Interventions to Decrease Risk for the Triad

Interventions for the Triad focus on improving low EA, as low EA results in the development of the other two interrelated components of the Triad: MD and low BMD [14,15]. Regarding the consumption of adequate EI to provide optimal EA, the attitude of female athletes needs to be reformed to see “food as fuel”, not as something that leads to weight gain [3]. In the past, the emphasis for interventions involving the Triad has been based solely on educating female athletes about the Triad [14].

These education-based interventions had positive effects on 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 [16-19]. 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 [20,21]. An intervention has not yet succeeded in positively influencing female athletes to improve their EI in free-living situations without providing caloric supplementation [16-21]. One option as a novel intervention for female athletes regarding the female athlete triad is an ecological momentary intervention.

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 [22]. EMIs provide support for participants in everyday life to aide in practicing new behaviors and developing new habits, which is ideal for changing dietary behaviors [23]. 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 [22].

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 [24-26], weight loss [27], treatment of bulimia nervosa [28], diabetes management [29-31], and even to increase adherence to applying sunscreen daily [32] to name a few. 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 [33]. Young adults, aged 18-29 years, send and receive 88 text messages per day on average [34]. 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 [35]. Text messages are very convenient for participants because they can be accessed and read at the time that is personally convenient to them [36].

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 [37]. Text messages deliver different types of prevention components based on theoretical models including the health belief model, and the theory of planned behavior [38]. Text messages also include important constructs including cues to action, social support and reinforcement, which are central to behavior theories whether or not the researchers intent was to base the content of the messages in theory behavior change [37]. 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 participants [39]. Heron and Smyth recommend that for behaviors that occur multiple times per day like smoking, several daily EMIs may be required [22].

The success of text messages as an intervention and for preventative behavior modifications [32] 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 [19]. Text message reminders have not been used with female athletes to improve EI, but may be a key route for an intervention program because they require little time and effort from female athletes [37] and provide a reminder in real-time to aid in a specific behavior change. The purpose of this study was to evaluate the usefulness of a brief EMI via text messages to increase EI in female athletes at risk for the Triad and to determine the utility of the EMI.

Materials and Methods

Participants

This study was reviewed and approved by the Utah State University (USU) Institutional Review Board. A total of 99 Division I female athletes from multiple sports teams at USU consented to participate. This study was a single center, mixed methods study. Female athletes from the following teams were recruited to participate: volleyball, softball, soccer, track and field/cross country, and the drill team and cheerleaders. These teams were recruited because female athletes participating at a high level of competition or who are participating in weight sensitive sports are at increased risk for the Triad [40-42]. All participants were invited to complete the screening questionnaire. Only those who were screened to be at risk for the Triad were invited to participate.

Measures used

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 [43]. The traditional method of assessing risk for the Triad was to analyze EA [4]. EA requires precise measurement of EI, EEE and body composition; measures difficult to obtain in clinical settings without trained researchers [44]. Analyzing EA can be difficult to assess and is not always a feasible option to assess risk for the Triad [44]. Many screening questions have been developed to assess possible risk for the Triad without measuring EA [43,45].

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 [43,45]. If an athlete is found 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 are warranted [45]. 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 [45].

In the present study, participants were directed to a website that was constructed by our researchers. Participants were prompted to register at our website where they provided their year in school, respective sport, phone number, email address, and cell phone provider. Participants were then asked to complete a questionnaire containing 40 questions related to general nutrition, sports nutrition and the Triad.

The first 13 questions were Triad screening questions recommended by the Female Athlete Triad Coalition in 2013 and 2014 [43,45]. The following 11 questions were included from the risk factors and warning signs of the Triad recommended by Javed, et al. [45]. These combined 24 questions were used as screening questions to assess whether female athletes were at risk for the Triad to participate in this study [45].

The remaining 16 questions were added to provide

Table 1: Triad screening questions (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 any type of DE?	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%	98%
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.

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. 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 1](#) and [Table 2](#) in the results section.

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 [43,45], and the 11 risk factors and warning signs of the Triad [45]. Participants were also assessed to be at risk if they indicated that they experienced less than 9 menstrual cycles in the past 12 months.

Diet: A diet recall was used to assess EI over three 24-hour (h) periods at baseline, and during the last three days 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). ASA24 was developed by the National Cancer Institute (Bethesda, MD, USA). Participants were instructed to track their diets on two weekdays, and one weekend day in order to capture their mean "usual" intake [46]. This 3-day, 24-h dietary recalls are considered the criterion standard for assessing an athlete's typical EI [47].

Exit survey: Upon the completion of the second and final 3-day, 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. The exit survey consisted of questions with Yes/No answers as well as a free response to clarify their answer further.

Materials

Triad video: Upon completion of the questionnaire, participants were directed to view a brief video (9:59 minutes) providing information about the Triad. The video was narrated by a Registered Dietitian (RD) who 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 signs of the Triad.

Ecological momentary intervention: Participants self-selected a total of two times per day that they would like to receive the EMIs in the form of text messages. Athletes were advised to select times during the day that they believed they would benefit from a text message reminder to prompt them to increase their EI. 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. The two times that participants selected to receive text message reminders remained the same each day throughout the intervention. Participants received the EMI via text message reminders for 14 days. On day 12 they were prompted to record their second set of 3-day, 24-hour dietary recalls while receiving the EMI via text message reminders. Text messages were simple and short, for example, a message that a participant

Table 2: Non-screening questions (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 body fat% 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%

Table 3: 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%

would receive if they had selected the breakfast category would be as follows: Breakfast is important to fuel your day!

Statistical Analysis

IBM Statistical Package for the Social Sciences (SPSS), version 22 was used to perform the statistical analysis. The responses from the qualitative exit survey were coded and grouped based on 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, to assess baseline demographics and whether they were at risk for the Triad or not. A p-value < 0.05 will indicate statistical significance. Fisher's exact test was performed for categories that contained cells with < 5, when you would expect there to be > 5 per cell. A paired T-test was used to assess change in EI pre-intervention and at the end of the 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 participants at risk, 32 (46.3%) completed the entire study. The questions and answers from the questionnaire are provided in Table 1 and Table 2.

The number of female athletes who reported having experienced a stress fracture presently or in the past indicating LBM density, was 25 (25.3%). The prevalence of female athletes using oral contraceptives to control MD was 15.2% (15), and those who reported experiencing MD was 38.7% (38). The average number of menstrual cycles that participants experienced in the last 12 months was 10.53 ± 3.33 ($p = 0.041$). Of those who were screened to be at risk for the Triad, 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 ($p = > 0.001$).

The percentage of at risk participants who responded "no" to the question "is it bad to skip your period", was 42% (29) ($p = 0.579$). 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 athletes "at risk" or "not at risk" for the Triad in their ability to name the three components of the Triad ($p = 0.382$).

The mean EI for the 3-day dietary recalls pre-EMI was $1906.29 \text{ kcals} \pm 563.4 \text{ kcals}$. The mean EI for the 3-day dietary recalls at the end of the EMI intervention was $1907.19 \text{ kcals} \pm 726.78 \text{ kcals}$, thus there was not a significant change in calories from the EMI ($N = 32$, $p = 0.237$). 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 ($p = 0.012$). Exit survey responses can be viewed in Table 3.

Qualitative results (N = 27)

58.3% of participants reported that they liked receiving the text message reminders and 11.1% reported that receiving the messages reminded them to eat. 40.7% (11) of participants disliked that the messages were sent at the same time every day. The main changes that participants (27.3%) reported that they would make to the text message reminders would be to receive < 2 messages per day (6). Participants (36.4%) also responded that they would like the opportunity to change the specific times of day that they received the messages each day, at 36.4% (8).

Discussion

The provision of text message reminders as an EMI to increase EI in participants did not result in a significant increase in kcals consumed before and at the end of the intervention. However, the text message reminders and nutrition education contributed 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. Even though they were able to

self-select two times per day that they would like to receive the messages, student athletes have different schedules each day. A time that might have worked for the female athlete to receive the messages on Monday may not be the time that would work for their specific schedule on Wednesday, or on the weekend. Participants also requested that the messages be motivational and provide information about WHAT to eat instead of reminding them to eat.

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 [48], and 60% of female triathletes had at least one component of the Triad [49].

41.4% (41) initially reported that it is not bad to skip your period, showing that there is a 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 eating disorders in a study by Beals and Hill, where 2.7% reported a history of DE [50]. Beals and Manore reported a prevalence of 5.6% of participants with a history of DE [42]. There was a change in Triad knowledge regarding the number of components that participants were able to name before and after 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.

Of the participants who completed their 3-day, 24-h dietary recall ($N = 32$), 56.3% (18) consumed fewer than 1906 kcals on average pre-intervention. According to the 2014 Female Athlete Triad Coalition, EI should be set at a minimum of 2000 kcals per day, with the goal to increase energy consumption based on specific (EEE) [43,51].

Text messages have worked successfully to influence behavior change in other populations and addressed many of the barriers previously identified for female athletes at risk for the Triad. EMI as text messages may not have been successful in increasing EI in this population, because there are other possible barriers that lead to low EA in female athletes that we did not address in this current study. This subset of female athletes battles many barriers to increasing their EI [45].

Some of the barriers that these athletes have that may lead to low EA and are listed in the following paragraphs. Athletes are perfectionists by nature, especially in sports where female athletes are only competitive for a limited number of years, or who have limited eligibility based on age (such as gymnastics) or scholarship [52]. 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 for some athletes [52]. 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 body fat for enhanced performance, which needs to be the goal before nutrition education can successfully be provided [52].

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.

A focus may need to be made on correcting additional 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. Another problem regarding DE is body dissatisfaction [53]. 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%). A focus on body satisfaction would be a beneficial direction to focus an intervention prior to attempting to increase EA in this population. Also, allowing participants to respond to the text message EMI would have provided a more interactive experience and may have resulted in a stronger effect on behavior change. For example, "Breakfast is important to fuel your day! Have you had breakfast today? Respond YES or NO".

Related to the EMI intervention, 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 schedules 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 [22]. Tailored, self-selected times daily would be a useful option for enhancing the text message EMI for this population moving forward.

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.

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 [54]. 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 [54].

We did not use EA to assess risk of the Triad; we used 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 for insight into the risk of the Triad in this population. Other strengths of this study include the use of ASA24 for the three-day dietary recall, using 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 athletes in the future. Another major strength of this study was the use of two 3-day food recalls at the start and end of the intervention. Although it is time consuming for the athlete, the two 3-day food recalls gave us insight to assess actual change in EI in kcals before the intervention and at the end of the intervention.

An EMI text messaging intervention that taught female athletes about the Triad and provided text message reminders about consuming kcals at times selected by the participants. Using text messages as an EMI is still a vi-

able option for this population, with some alterations to the format of the messages, and allowing different times per day that athletes can select to receive the messages.

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