

EDUCATIONAL INTERVENTION IMPROVES FEMALE ATHLETE TRIAD AWARENESS IN FEMALE COLLEGIATE SWIMMERS

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BACKGROUND: The Female Athlete Triad (Triad) is characterized by high energy expenditure and low caloric intake, leading to dysregulation of menstruation and bone metabolism. Triad-associated relative energy deficiency in sport (REDs) adversely affects performance and mental health. Risk factors are underrecognized in swimmers, who are less likely to present with bone stress injuries because of swimming's non-weightbearing nature. Our objective was to quantify knowledge about the Triad and REDs among collegiate swimmers and demonstrate the value of educational intervention.

METHODS: Members of two Division III women's varsity swim teams completed a Qualtrics survey, consisting of 35 Triad and REDs questions, and 13 demographics questions. Participants then attended an in-person, 20-minute educational session focused on Triad risk factors and prevention, after which they completed a post-session survey. The post-session survey contained 13 additional questions about their opinions of the education session using a Likert scale, where 1=Strongly Agree and 5=Strongly Disagree. Pre- and post-session data were analyzed using Microsoft Excel.

RESULTS: Thirty-one female-identifying swimmers were included. Pre-session, 5 of 31 (16.1%) respondents named one or more Triad components, compared to 30 of 31 (96.8%) after ($p < 0.0001$). 5 of 31 (16.1%) could define the REDs acronym pre-session, compared to 19 of 31 (87.1%) after ($p < 0.0001$). Participants better understood the Triad post-session (mean Likert score = 1.23) and found the session helpful (mean = 1.23), but in a hypothetical scenario, felt relatively uncomfortable contacting medical staff about Triad symptoms (mean = 1.87, $p = 0.0002$). Of the 11 respondents (35.5%) who believed they may be experiencing Triad components, 8 (72.7%) indicated the session motivated them to seek help.

CONCLUSION: Female collegiate swimmers' low baseline Triad and REDs knowledge improved significantly after an educational intervention. Survey responses highlighted the importance of heightened Triad awareness, but also its continued stigmatization among swimmers. The session encouraged swimmers with self-identified Triad symptoms to seek help, underscoring the importance of continued education efforts, especially in sports where the Triad is underrecognized.

INTRODUCTION

Young female athletes are at high risk of developing musculoskeletal issues related to insufficient nutrition. In 1992, the American College of Sports Medicine coined the "Female Athlete Triad" (Triad), which encompasses energy insufficiency, amenorrhea, and low bone mineral density.^{1,2} The prevalence of the Triad with all three components has been estimated as high as 15.9%, while recorded prevalence of the Triad with one or two triad components have been estimated as high as 60.0% and 27.0%, respectively.³ In recent years,

the preferred terminology has been expanded to "Relative Energy Deficiency in Sport" (REDs), a more complex condition referring to all downstream complications of the energy imbalance resulting from a high degree of exercise in the setting of insufficient nutrition.⁴ Numerous studies have shown an association between the Triad or REDs and musculoskeletal injuries, particularly emphasizing that athletes at moderate or high risk for the Triad had higher rates of bone stress fractures.⁵⁻¹⁰ Furthermore, these conditions have

been linked to mental health concerns and poor athletic performance.⁴

The Triad and REDs have been traditionally studied in female athletes participating in aesthetic sports, or sports where the body's physical appearance is emphasized, such as gymnastics, figure skating, dancing, and long-distance running.^{5-7,11} Previous research has shown that athletes in aesthetic sports report high drives for thinness, self-objectification, body surveillance, body shame, and disordered eating behaviors.¹¹ As such, these populations have often been the targets of interventions, with studies in dancers showing that knowledge of the Triad/REDs can be improved through educational videos.^{12,13} However, as bone stress injuries (BSI) are commonly the initial presenting symptom that prompts evaluation for the Triad/REDs in athletes, these conditions are more likely to be diagnosed in athletes participating in sports involving a large weightbearing component.^{1,2,14-17}

Consequently, the Triad and REDs may go unrecognized in non-weightbearing sports such as swimming. Swimmers less frequently suffer from BSIs, despite the fact that non-weightbearing training often predisposes them to a lower bone mineral density compared to other athletes.^{18,19} While swimmers may develop BSIs during off-season weightbearing training sessions, during non-weightbearing training sessions in the water during their competitive seasons, they may have underlying components of the Triad or REDs without having a BSI.¹⁷⁻¹⁹ This may lead to missed opportunities for education and interventions to help improve their health, performance, and overall well-being both in the immediate future and long-term. Without Triad/REDs education, these athletes will still be at risk for Triad/REDs downstream sequelae, including clinical eating disorders and associated psychological comorbidities, osteopenia and osteoporosis, and luteal phase defects and anovulatory cycles.²⁰ It is important to understand the extent to which these athletes are aware of and evaluate themselves for symptoms that can lead to future development of these serious outcomes.²⁰⁻²²

The aim of this study was to evaluate female collegiate swimmers' awareness of the Triad and REDs, as well as the impact of an educational intervention on this level of awareness and willingness to seek treatment or advice for their conditions. We hypothesized that swimmers would

have a low level of awareness of these conditions, which would be amenable to education on the topic.

METHODS

Participant Recruitment

Female-identifying, varsity collegiate swimmers aged 18-23 from two Division III universities were invited to participate in the study. The senior author of this study contacted the women's swimming coaches and athletic trainers at each university and obtained permission to hold an education session ("session") about the Triad and REDs for the swimmers as part of a research study. Inclusion criteria consisted of participation on a varsity collegiate swimming team and identifying as female, while exclusion criteria included age less than 18 years or greater than 23 years. Prior to administration of the survey and the education session, written informed consent was obtained from all participants. This research was approved by the Johns Hopkins Medicine Institutional Review Board, under the ID# IRB00390015.

Education Session

The education session began after all participants completed the pre-session survey. The session consisted of a 31-slide PowerPoint presentation, which was presented over the course of approximately twenty minutes. The PowerPoint was created by the senior author (an attending physician) and presented jointly by a medical student and the senior author. Subtopics within the presentation included Triad risk factors and warning signs, symptoms of and body systems impacted by REDs, Triad- and REDs-associated vitamin and mineral deficiencies, and Triad and REDs prevention and treatment options. There was time allotted for questions from the participants after each subsection and after the conclusion of the presentation, all of which were answered by the senior author.

Survey Format

Participants were asked to complete a Qualtrics survey (Qualtrics, Provo, UT) before and after the education session. The survey was administered electronically, and participants took the survey individually on mobile devices or laptops. Participants were asked not to look up any information they did not know while taking the survey, and they were encouraged to complete the survey at their own pace. The study team ensured each participant had finished the survey before

moving to the subsequent portion of the study. The pre-session survey consisted of 35 questions that assessed knowledge of the Triad and REDs, and 13 demographics questions. The knowledge questions included true/false and open-ended formats that investigated factual knowledge about the conditions, as well as athletes' individual experiences with each condition. Certain responses to the questions above prompted free-response follow-up questions, which were compiled and analyzed by the study's lead author, who performed the data analysis.

Immediately following the education session, participants were asked to take the post-session survey, which consisted of the same 35 Triad and REDs knowledge questions, as well as 13 post-session questions. The post-session questions were formatted as a Likert scale, where respondents were asked to rate how much they agreed with a provided statement on a scale from 1 (strongly agree) to 5 (strongly disagree). These questions assessed participants' opinions of the utility of the education session, as well as if participants felt that any topics taught during the education session were applicable to themselves. The post-session survey also asked respondents about their own experiences with Triad and REDs symptoms. The conditions under which the participants took the post-session survey were identical to those for the pre-session survey.

Survey response data was analyzed using the Qualtrics software and Microsoft Excel (Microsoft Corporation, Richmond, WA). Qualitative analysis was performed to describe anecdotal responses. One-way ANOVA and Tukey's post-hoc analysis were used to compare Likert responses among a series of post-session questions. Significance level was set at 0.05 for all t-tests.

The complete survey is included in Appendix 1.

RESULTS

Demographics

There were 33 swimmers who completed the pre-session survey, and 31 swimmers who completed the post-session survey. The two swimmers who did not complete the post-session

survey were excluded from analysis. 10 swimmers self-identified as Asian, 2 self-identified as Black or African American, 1 self-identified as Native Hawaiian or Pacific Islander, and 25 self-identified as White, noting that participants were permitted to select more than one response. The mean age of the cohort was 18.97 years (standard deviation [SD] 1.07, range 18-21 years), mean height was 65.86 inches (SD 2.56, range 61-71 inches), and mean weight was 152.24 pounds (SD 31.43, range 103-239 pounds), calculating to a mean body mass index of approximately 24.5 kg/m². Average age of first menarche was 12.48 years (range 10-15 years). Respondents reported a mean of 11.06 years (SD 2.16, range 7-15 years) of competitive swimming up until the date of the survey.

Triad and REDs Knowledge Assessment

In the section of the survey that assessed knowledge of the Triad and REDs, 5 of 31 (16.1%) respondents had heard of the Triad prior to the session compared to 30 of 31 (96.8%) after the session ($p < 0.0001$). Similarly, 5 of 31 (16.1%) respondents had heard of REDs prior to the session, compared to 31 of 31 (100%) after the session ($p < 0.0001$). In an open-response format, 1 of 31 (3.2%) respondents could correctly name all three components of the Triad prior to the session, compared to 19 of 31 (61.3%) after the session. 5 of 31 (16.1%) respondents and 3 of 31 (9.7%) respondents could write out what the REDs acronym stood for and list ways REDs can affect overall wellbeing prior to the session, respectively. After the session, those numbers improved to 27 of 31 (87.1%) and 31 of 31 (100%), respectively.

Of the 11 true/false questions testing factual knowledge, a statistically significant increase in correct responses between the Pre- and Post-Session surveys was observed in response to 2 questions. Those two statements were "skipping or losing my period while playing sports is normal" (the correct answer is FALSE, $p < 0.001$), and "stress fractures occur more often in girls who skip their periods" (the correct answer is TRUE, $p = 0.012$). All results from the true/false portion of the survey are outlined in Table 1.

Table 1. True/False Responses to Triad and REDs Knowledge Questions

<i>True/False Question</i>	<i>Correct Answer</i>	<i>N (%) Correct Pre-Session</i>	<i>N (%) Correct Post-Session</i>	<i>p-value</i>
<i>Skipping or losing my period while playing sports is normal</i>	FALSE	18 (59.1%)	29 (93.5%)	0.0055
<i>A menstrual cycle typically occurs every 28 +/- 7 days</i>	TRUE	31 (100%)	30 (96.8%)	0.31
<i>I am old enough to have bones that fracture easily</i>	TRUE	6 (19.4%)	7 (22.6%)	0.89
<i>Female athletes who skip their period don't have increased difficulty becoming pregnant</i>	FALSE	24 (77.4%)	27 (87.1%)	0.25
<i>Not eating enough calories could cause me to skip or lose my period</i>	TRUE	29 (93.5%)	30 (96.8%)	0.60
<i>Stress fracture risk is not influenced by the number of calories I consume</i>	FALSE	28 (90.3%)	29 (93.5%)	0.44
<i>Stress fractures occur more often in girls who skip their period</i>	TRUE	24 (77.4%)	30 (96.8%)	0.015
<i>Low energy availability can impair performance</i>	TRUE	31 (100%)	31 (100%)	1
<i>Low energy availability can affect sleep and mental health</i>	TRUE	30 (96.8%)	31 (100%)	0.34
<i>Low energy availability does not affect other body systems, including the cardiovascular and gastrointestinal systems</i>	FALSE	28 (90.3%)	28 (90.3%)	0.76
<i>Low energy availability can weaken the immune system</i>	TRUE	31 (100%)	30 (96.8%)	0.31

Bolded percentages in the TRUE and FALSE columns indicate the correct response to the corresponding statement. Bolded P values represent statistically significant differences ($p < 0.05$) between the Pre- and Post-Session responses.

Table 2. Responses to Individual Experiences with Triad or REDs Components

Question	Yes	No	Unsure
<i>Have you previously been told that it is normal to miss your period if you are an athlete/exercising hard?*</i>	18 (58.1%)	10 (32.3%)	3 (9.7%)
<i>Do you follow any specific dietary restrictions or avoid certain foods when you're in season?*</i>	9 (29.0%)	22 (70.1%)	
<i>Do you follow any specific dietary restrictions or avoid certain foods when you're out of season?*</i>	8 (25.9%)	23 (74.2%)	
<i>Have you ever had a stress fracture?*</i>	4 (12.9%)	22 (70.1%)	5 (16.1%)
<i>Have you ever had a DEXA scan?</i>	1 (3.2%)	28 (90.3%)	2 (6.5%)
<i>Are you taking any female hormones?*</i>	17 (54.8%)	14 (45.2%)	
<i>[Asked to those who responded No to the above question] Do you have regular periods? (Once every 28 days)</i>	9 (64.3%)	5 (35.7%)	
<i>Do you have regular periods? (Once every 28 days)*</i>	15 (48.4%)	15 (48.4%)	1 (3.2%)
<i>[Asked to those who responded No or Unsure to the above question] Do you think that missing your period correlates with the intensity of your training?</i>	10 (62.5%)	3 (18.8%)	2 (12.5%)
<i>Are you currently happy with your weight?*</i>	16 (51.6%)	12 (38.7%)	3 (9.7%)
<i>Have you ever been diagnosed with an eating disorder?</i>	3 (9.7%)	28 (90.1%)	
<i>Do you have any vitamin or mineral deficiencies?*</i>	7 (22.6%)	16 (48.4%)	11 (35.5%)

Individual Experiences with Triad or REDs Components

In response to the survey questions asking about personal experiences with topics related to the Triad or REDs, the majority of respondents had been told it was normal to miss one's period if one was an athlete or exercising vigorously. Over half of the respondents reported that they did not experience regular periods, or were unsure if their periods were regular. Of these respondents, the majority believed that their period irregularity correlated with the intensity of their training. These responses and other questions that elicited a "yes" or "no" response from this section are recorded in Table 2.

The majority of respondents who indicated they had previously been told that it was normal to miss one's period as an athlete reported they learned this from a medical provider (Figure 1a). The majority of respondents who followed dietary restrictions in or out of season said that their main dietary change was to eat less sugar or "unhealthy" food. Respondents who reported menstrual irregularity or were unsure if they had regular periods were asked if there were times or circumstances where they noticed that they got their period less often, summarized in Figure 1b. After being prompted if they were happy with their

weight, 14 respondents (45.2%) said they were trying to lose weight, 3 (9.7%) said they were trying to gain weight, 7 (22.6%) said they were trying to stay the same weight, and 7 (22.6%) said they were not really thinking about their weight. Respondents were also asked if they had any history of mood or mental health disorders, described in Figure 1c.

Post-Session Survey Responses

The post-session questions that participants disagreed with most strongly, corresponding to higher numerical Likert scores, were "I would feel comfortable reaching out to athletic training/medical staff if I thought I was experiencing Triad or REDs symptoms" and "I would feel comfortable encouraging a teammate to seek help if I think they are experiencing Triad or REDs symptoms" (Table 3). One-way ANOVA and Tukey's post-hoc analysis showed that the former question had a significantly higher average Likert score than questions 1, 2, 3, and 4, and the latter question had a significantly higher Likert score than all other questions in this section. Participants' responses to questions about their own personal experiences with the Triad or REDs symptoms are summarized in Table 4.

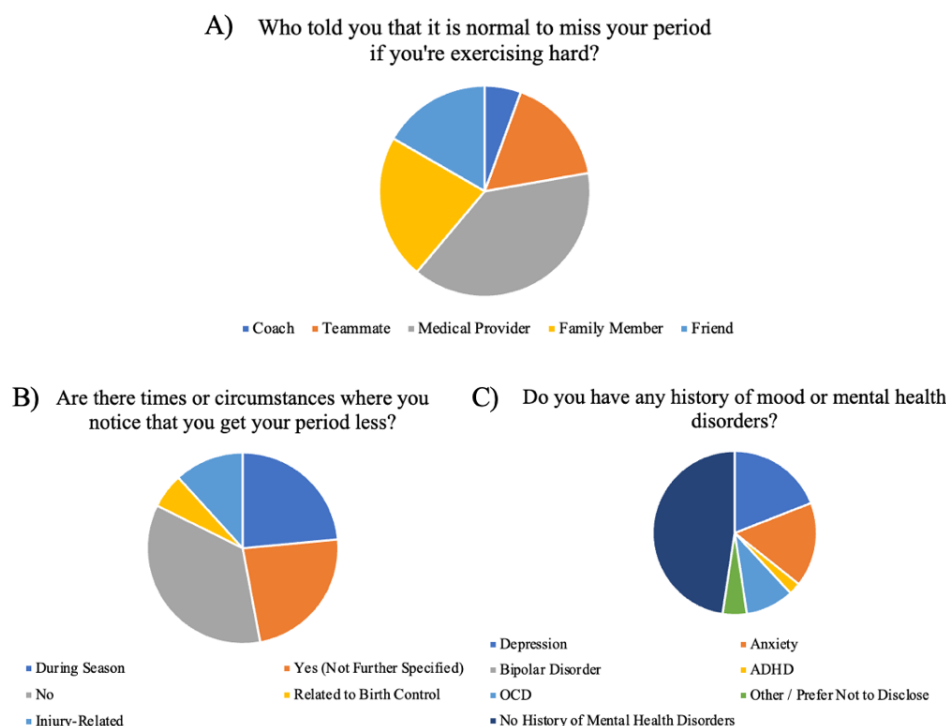


Figure 1. Responses to Select Follow-Up Questions. Distribution of open-ended responses to the questions are listed

Table 3. Average Likert Score responses to post-session questions

Question	Average Likert Score	Standard Deviation
1. I learned something new at this presentation	1.19	0.40
2. I better understand the female athlete triad after attending this presentation	1.23	0.43
3. I better understand REDs after attending this presentation	1.26	0.44
4. I found this presentation helpful or informative	1.23	0.43
5. This presentation was relevant to swimmers in particular	1.52	0.68
6. I paid attention to the entire presentation	1.55	0.57
7. I would feel comfortable reaching out to athletic training/medical staff if I thought I was experiencing Triad or REDs symptoms	1.87	0.81
8. I would feel comfortable encouraging a teammate to seek help if I think they are experiencing Triad or REDs symptoms	2.81	1.28

Table 4. Responses to post-session questions about personal experiences with triad or REDs Symptoms

Question	Yes	No	Not Sure
I think I'm experiencing one or more components of the female athlete triad	7 (22.6%)	20 (64.5%)	4 (12.9%)
[Asked to those who responded Yes or Unsure to the above question] This presentation motivated me to seek help for a Triad component I may be experiencing	8 (72.7%)	3 (27.3%)	
I think I am experiencing one or more REDs symptoms	6 (19.4%)	20 (64.5%)	5 (16.1%)
[Asked to those who responded Yes or Unsure to the above question] This presentation motivated me to seek help REDs symptoms I may be experiencing	8 (72.7%)	3 (27.3%)	
I think one or more of my teammates may be experiencing a Triad component	14 (45.2%)	17 (54.8%)	
I think one or more of my teammates may be experiencing REDs	15 (48.2%)	16 (51.8%)	

DISCUSSION

The present study found that swimmers had a low baseline awareness of the Triad and REDs, but were amenable to education on this topic. Supporting this, we found that only 16% of the swimmers had heard of the Triad and REDs prior to

our education session. Our study also showed not only that the education session improved knowledge of the Triad and REDs, but also that the participants found it valuable, and that it encouraged some of them to seek help for Triad or REDs symptoms.

Two questions showed a significant difference in correct answers pre- and post-educational session: “skipping or losing my period while playing sports is normal” (the correct answer is FALSE) and “stress fractures occur more often in girls who skip their periods” (the correct answer is TRUE). The fact that both questions were on the topic of menstrual health identified this topic as an area that both needs and can benefit from targeted education. Because menstrual dysfunction is common in female athletes, there is a common misconception that amenorrhea or oligomenorrhea is a normal result of intense exercise, in the absence of other intervening factors that alter menstrual cycles, such as intrauterine devices.²³ Teaching and emphasizing to young athletes that amenorrhea indicates that the body may be failing to meet energy requirements would be a beneficial intervention so that Triad symptoms can be caught and corrected early in its development.²³ Further, the connection between amenorrhea and systemic sequelae, such as BSIs, is a crucial point of emphasis in Triad education, especially so that athletes understand the gravity of sustained amenorrhea.²⁴ This relationship is important to recognize in young athletes, who may already be experiencing the negative associated effects; one study showed that adolescent athletes with amenorrhea had lower bone density z scores at the spine and whole body compared to eumenorrheic athletes.²⁵

A surprising finding of this study was that a majority of respondents reported they were told by healthcare providers that missing their period is normal. Healthcare providers – including physicians, athletic trainers, physical therapists, and more – who are involved in the care of these athletes may thus be another population to target with Triad education to ensure dissemination of accurate information. A recent survey among physicians of different specialties underscored the need for targeting Triad education to healthcare providers: baseline Triad and REDs awareness was highest in doctors specializing in orthopaedic surgery (100%), followed by physical medicine and rehabilitation (70%) and family medicine (67%), and was lowest in endocrinology (33%), followed by pediatrics (45%).²⁶ Importantly, it was shown that Triad/REDs awareness did increase among these physicians in a follow-up survey administered at a later date.²⁶ The discordance between specialties regarding baseline level of knowledge of the Triad and REDs is something that can and should be corrected. Especially in a sport like swimming,

where BSI rates and therefore Triad screening rates are lower, educating primary care providers about Triad symptoms and implementing a Triad screening component to annual physicals could help identify at-risk young women and prevent progression of symptoms.¹⁷ Further, literature has shown that coaches may also share these misconceptions about amenorrhea and can pass them down to athletes.²⁷ It is imperative that not only female athletes can recognize signs of the Triad, but also that authority figures in their lives can recognize the signs, so they can encourage athletes suffering from amenorrhea to seek help and remain healthy.

Another observation surrounded the question “I am old enough to have bones that fracture easily”. The correct answer was TRUE, but the percentage of correct answers was markedly low in both the pre- (19.4%) and post-session (22.6%) surveys. Our college-age participants, aged 18-21, are certainly at ages where they are prone to stress fracture, especially if they experience Triad symptoms. One investigation of 196 stress fractures found the mean age of patients with stress fractures to be 20.1 years, with the lower limit being 10 years.²⁸ Stress fracture risk is elevated in female athletes, especially in women suffering from Triad symptoms, and is more common in girls who participate in sports for 8 or more hours per week, which is significantly less than the weekly sport participation for any collegiate athlete.^{29,30} Consequently, our takeaway from the persistently low correct response rate to this question about bone health was that in Triad education, heightened risk of stress fracture, regardless of age, is a topic that needs to be explained more explicitly.

The most negative responses observed in the post-session survey were related to comfort with speaking up about concerns regarding Triad/REDs symptoms for themselves or for a teammate. These findings align with a multitude of previous studies demonstrating that women face stigmas against speaking up about female health issues, as well as feelings of invalidation in medical contexts.³¹⁻³⁶ While BSIs are frequently the symptom that prompts evaluation for the Triad or REDs, amenorrhea is a predisposing independent risk factor that can present much earlier.³⁷ However, because amenorrhea is unfortunately common among young, high-intensity female athletes, their hesitancy to seek help may be bolstered by a continued stigma surrounding female health, as well as a fear of invalidation among medical

providers.³⁸ Negative stigmas associated with disordered eating may also discourage those affected from speaking up, especially in sports where aesthetics are emphasized.^{6,32} Further, at a high level of athletic competition, female athletes are more likely to have male coaches, and mutual discomfort or embarrassment may limit the extent to which healthy communication about female health can be productive.^{31,33}

Together, these results show a marked improvement in Triad and REDs awareness after an educational intervention, which has the potential to translate clinically if athletes are truly motivated to seek help after the session. The low baseline knowledge of the Triad aligns with previous surveys of female collegiate swimmers, with one such study showing a lack of knowledge regarding nutrition and how it can impact performance, as well as a lack of awareness that male and female swimmers are not achieving adequate energy intake.^{39,40} Similar to our study, researchers have shown an increased awareness of the Triad and REDs following an educational session developed for dancers, manifesting as improvement in factual knowledge about the Triad from a baseline of less than 50% correct responses before their video-based intervention.^{12,13} Our study identified another at risk population that could benefit from this education. The combination of insufficient nutrition knowledge and intake coupled with low awareness of the Triad and REDs further supports the need for educational interventions to provide swimmers and other athletes with this information to optimize their health and performance. Further, the fact that the presentation led to a notable proportion of participants recognizing Triad and REDs symptoms in themselves, and that the presentation motivated the majority of those participants to seek help, speaks to the impact and value of Triad education, especially in sports lacking adequate screening.

Our study has many strengths, however, it also must be interpreted in the context of its limitations. Our small sample size may limit generalizability. We were unable to follow up with the cohort long term to assess retention, though that would be a promising future direction for this study. We did not control for the effect of hormonal birth control usage, nor comorbid conditions that may affect menstrual health or bone density, on survey responses. In addition, while we adapted some questions from other similar survey questions that have previously been used, we did not use a validated survey or educational PowerPoint.^{12,13}

Since factual education is imperative for the health of our young athletes, it would be beneficial to develop standardized education.

CONCLUSION

This study showed that an educational intervention can raise awareness of the Triad and REDs. It would be beneficial for educational sessions to be implemented for athletes in other sports, intervening at younger ages, such as adolescents, and providing additional information depending on the particular female athlete population. This increased awareness may aide athletes to recognize and speak up about their health concerns and undergo screening and evaluations to optimize their medical care and sports performance.

Conflict of Interest Statement

Authors declare the following conflicts of interest: Andrew Cosgarea MD has received textbook royalties from Elsevier and is part of the board for Knee, Orthopaedic Journal of Sports Medicine, Patellofemoral Foundation, and Sports Medicine and Arthroscopy Review. Dawn LaPorte MD is part of the board for American Orthopaedic Association, American Society for Surgery of the Hand, Perry Initiative, Ruth Jackson Orthopaedic Society, and Journal of Hand Surgery. Jessica Schmerler is part of the board for Ruth Jackson Orthopaedic Society.

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