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Screening for Relative Energy Deficiency in Sport and Female Athlete Triad: A Survey of Pediatric Sports Medicine Professionals

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BACKGROUND: Relative Energy Deficiency in Sport, or RED-S, is a multi-scale physiological response to a mismatch between energy intake and exercise energy expenditure that affects up to 50% of adolescent athletes. RED-S symptomology was first described as the Female Athlete Triad (the Triad) and includes specifically low energy availability with or without disordered eating, menstrual dysfunction, and low bone mineral density. Despite the wide impact of RED-S/the Triad, there is a lack of standardization of screening in adolescent athletes. Therefore, the purpose of this study was to assess if there are differences in practitioner demographics when screening for RED-S/the Triad in adolescent athletes. In addition, we sought to assess if providers' screening habits differ based on specific patient characteristics.
METHODS: We conducted a cross-sectional online questionnaire of members of the Pediatric Research in Sports Medicine (PRiSM) Society. PRiSM is an interdisciplinary group of professionals who are dedicated to advancing the research and medical care of young athletes. The questionnaire assessed screening tools that members used to assess for RED-S/the Triad, practices implemented when providers were concerned for RED-S/the Triad, demographic data, and type of training.
RESULTS: Of 389 PRiSM members, 60 completed the survey and were included in subsequent analyses (15% response rate). Most participants were primary care sports medicine physicians (37%), orthopaedic surgeons (27%), or physical therapists (23%), and about half of respondents identified as a *cis* gender woman (55%). There was a trend toward more women screening for RED-S routinely than men (55% vs. 33%: p=0.10), and orthopaedic surgeons were less likely to screen than other specialties (25% vs. 52%, p = 0.06). Eating disorders (88%), menstrual dysfunction (76%), and bone stress injury (74%) were reported as specific red flags that make providers screen for RED-S/the Triad. Participants reported that lack of time (57%) and lack of resources (37%) were barriers to screen for RED-S/the Triad. The most commonly utilized tools to screen for RED-S/the Triad were the Female Athlete Screening Tool (FAST), Female Athlete Triad Risk Scale, Female Athlete Triad Consensus Panel Screening questions, and RED-S Specific Screening Tool (RST).
CONCLUSION: Orthopaedic surgeons were less likely than other health care professionals to screen for RED-S/the Triad. Barriers that prevent healthcare providers from screening for RED-S/the Triad included limited time and resources. By describing current practices, we have identified gaps and areas of need to enhance screening for RED-S/the Triad across multiple sports medicine disciplines.

INTRODUCTION

Relative Energy Deficiency in Sport, or RED-S, affects between 22-58% of male and female adolescent athletes.[1] The model of RED-S encompasses impaired physiologic functioning of multiple body systems secondary to low energy availability (e.g. a mismatch in energy intake and exercise energy expenditure).[1,2] The negative impact of inadequate energy intake on bone health and reproductive function in females is commonly referred to as the female athlete triad (the Triad).[1-3] The Triad is considered a continuum characterized

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by low energy availability with or without disordered eating, menstrual dysfunction, and low bone mineral density (BMD), with the most severe conditions presenting as clinical eating disorders, osteoporosis, and secondary amenorrhea.[3] RED-S includes the Triad but expands upon the physiologic functions that can be negatively impacted by low energy availability, ranging from stunted growth and hormonal changes, to impaired immune function, as well as potentially reduced vascular endothelial function and unfavorable lipid profiles.[2] Early identification and rapid intervention is important to prevent the negative long-term effects of RED-S/the Triad.[3] These long term effects include poor bone mineral density and osteoporosis, elevated cortisol levels, hypothyroidism, and difficulty becoming pregnant.[4,5]

Screening for RED-S/the Triad can be described as an "active search" for at-risk athletes, and healthcare professionals often use screening tools to identify symptoms and risk factors.[6,7] Screening generally includes a detailed medical history with a focus on eating behaviors, training level, weight changes, bone health, injury history, hormone usage, and menstrual history (in those who menstruate).[3,6] It has been recommended that health care professionals screen athletes at least annually during pre-participation examinations (PPE) as well as when an athlete presents with one component of the Triad.[3] This is because it is likely that other components are present if one issue is discovered, and athletes may need different treatment based on which components are present.[8]

There is a variety of questionnaires and other tools at the disposal of healthcare professionals to utilize when screening for RED-S/the Triad. One recent study found 13 different questionnaires tailored towards identifying common symptomology and/or risk factors for RED-S and the Triad, however, not all of these are validated in adolescent athletes.[7] Due to the lack of agreement and gold standard in screening practices for RED-S/the Triad, it is important to understand what tools and practices healthcare professionals are actively using, or if screening is even a common practice in adolescent athletes. The effects of failing to identify adolescent athletes at risk for or with RED-S/the Triad can lead to long-term impairments in bone health, endocrine function, and reproductive function.[1,2] Prior studies showed healthcare professionals have low awareness of and knowledge regarding RED-S/the Triad, which leads to concern that they are not adequately screening for these conditions.[9-12] Thus, in order to optimize early detection and intervention, the common screening practices and associated factors (i.e. healthcare specialty, age, gender, etc.) must first be identified.

Therefore, our first aim of this study was to assess if there are differences in practitioner gender and healthcare specialty when screening for RED-S/the Triad in adolescent athletes. In addition, we sought to assess if providers' screening habits differ based on specific patient characteristics. We hypothesized that female healthcare professionals and primary care sports medicine physicians would be more likely to screen adolescent athletes for RED-S/the Triad than male healthcare professionals and other types of sports medicine health care professionals (orthopaedic surgeons, physical therapists, athletic trainers, advance practice providers). We also hypothesized that healthcare professionals would be more likely to screen adolescent athletes with bone stress injuries. By describing pediatric sports medicine healthcare professionals' practices, we hope to improve screening of young athletes for RED-S/the Triad.

METHODS

Survey Development and Distribution

We conducted a survey-based cross-sectional study to assess RED-S/the Triad screening practices of members of the Pediatric Research in Sports Medicine (PRiSM) society, comprised of professionals who are dedicated to advancing the research and medical care of young athletes. Most members are based within the United States. PRiSM members work regularly in various clinical and research settings with young athletes and can serve an important role in screening for RED-S/the Triad. Surveying members of PRiSM allowed for the assessment of screening practices across a variety of sports medicine disciplines, which can inform where efforts should be made to enhance screening practices for RED-S/the Triad.

Survey questions focused on screening tools that members used to assess for RED-S/the Triad as well as practices implemented when providers were concerned for RED-S/the Triad (Supplemental Figure 1). The survey was developed prior to the 2023 annual PRiSM meeting and all members of the Female Athlete Research Interest Group provided feedback on survey content during the annual meeting. The PRiSM Scientific Committee provided approval of the final version before distribution to membership. A link

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to the electronic survey via REDCap was sent out by the PRiSM society to all 398 members on July 13th, 2023. All PRiSM members who completed the survey by July 21st, 2023, were included. Seventy-eight individuals began the survey and sixty (15% of the membership) completed the survey and were included in analysis.

Ethical Considerations

Participants were required to read and express understanding of an informed consent form on the first page of the REDCap survey prior to viewing and completing the survey questions. The protocol was approved by the local Institutional Review Board (#23-0302).

Grouping and Outcome Variables

Questions assessing demographics and professional background including gender identity, region of practice, professional training, and years in practice were included at the beginning of the survey. To examine our primary aims, participants were asked "Do you screen your patients for RED-S/the Triad, or does your electronic medical record (EMR) have a system to screen for RED-S/the Triad?" Respondents were grouped by the frequency reported (Always/Most of the time/Sometimes vs. Occasionally/No).

We also asked participants to indicate if any physical conditions or injuries (i.e. stress fracture, acute fracture, bony abnormality, tendonitis, concussion etc.) in patients affected the likelihood of a patient being screened for RED-S/the Triad.

Statistical Analysis

Descriptive data are presented as mean (±SD) for continuous variables, and the number included and corresponding percentage within group for categorical variables. To test our hypotheses, we first compared participant characteristics between groups using independent-samples t-tests (for continuous variables) and chi square analyses (for categorical variables). We constructed several grouping variables, including type of training, frequency of screening for RED-S/the Triad, medical conditions that lead the healthcare professional to screen, and barriers to screening. We then compared responses between groups on the screening frequency and patient conditions using chi square analyses. All other data is presented descriptively. All statistical tests were two-sided, evaluated using a significance level of $\alpha = 0.05$, and performed using Stata Statistical Software: Version 16 (StataCorp, LLC, College Station, TX, USA).

RESULTS

Sixty participants completed the survey (55% females and 45% males). PRiSM membership has 48% females and 52% males. Most participants were primary care sports medicine physicians, orthopaedic surgeons, or physical therapists (Table 1). The percentages of the full PRiSM membership were similar to the respondents (9% of members listed other or researcher/scientist as their training discipline). There was no significant difference between the amount of time spent in practice for women vs men (11.2 years vs 13.8 years, p=0.16). Forty-five percent (n=27) of participants (55% of women and 33% of men, p=0.10) reported screening patients for RED-S/the Triad all of the time, most of the time, or sometimes (Table 1).

When evaluating type of education or training and screening practices, there were no statistically significant differences between any specific group (Table 2). However, there was a lower percentage of orthopaedic surgeons who screened for RED-S/the Triad compared to other specialties (25% of orthopaedic surgeons vs 52% of all other specialties, p=0.06).

When participants were asked what specific issues, diagnoses, or symptoms that make them ask about RED-S/the Triad, the most commonly reported were disordered eating/eating disorder (88%), menstrual dysfunction (76%), and bone stress injury (74%). Only 41% reported always screening during the preparticipation physical evaluation (Table 3).

Several barriers were reported by participants as reasons why they may not screen patients for RED-S/the Triad (Table 4). The most common barriers were lack of time with patient (57%) and lack of resources/referral sources (37%).

Participants reported using a number of tools when screening for RED-S/the Triad. The Female Athlete Screening Tool (FAST), Female Athlete Triad Risk Scale, Female Athlete Triad Consensus Panel Screening questions, and RED-S Specific Screening Tool (RST) being the most common tools (Table 5). At least 14 participants (>25%) responded they always or sometimes use these tools.

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Table 1. Comparison between cis-gender women and cis-gender men survey respondents. Continuous variables are presented as median [interquartile range], categorical variables are presented as n (%)

	Variable	*Total (N = 60)*	*Full membership*	*Cis gender women (N = 33)*	*Cis gender men (N = 27)*
Training	Primary Care Sports Medicine	22 (37%)	25%	10 (45%)	12 (55%)
	Orthopaedic Surgery	16 (27%)	32%	6 (38%)	10 (63%)
	Physical Therapist	14 (23%)	20%	10 (71%)	4 (29%)
	Athletic Trainer	4 (7%)	8%	4 (100%)	0 (0%)
	Nurse Practitioner Advanced Practice Nurse	3 (5%)	3%	2 (66%)	1 (33%)
	Physician Assistant	1 (2%)	3%	1(100%)	0 (0%)
Time spent in practice (years)		12.3 (7.1)		11.2 (6.6)	13.8 (7.5)
Participants screen patients for RED-S and/or the Female Athlete Triad? (Always, most of the time, or sometimes)		27 (45%)		18 (55%)	9 (33%)

Table 2. Comparison of RED-S screening practices based on type of training. Total numbers and percentage for each group are presented

Type of training	*Screen patients for RED-S/Triad (N=27)*	*P value*
Primary Care Sports Medicine (N=22)	11 (50%)	0.55
Orthopaedic Surgeon (N=16)	4 (25%)	0.06
AT or PT (N=18)	9 (50%)	0.61
NP or PA (N=4)	3 (75%)	0.32

AT, athletic trainer; PT = physical therapy; NP, nurse practitioner; PA, physician assistant
P-values represent the comparison of the group represented in each row compared to the other three specialties

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Table 3. Specific issues, diagnoses, or symptoms that elicit asking about RED-S/Triad, presented as n (%)

Issue, diagnosis, or symptoms to ask about RED-S/Triad	*Always screen*	*Screen only in the presence of another factor or not at all*
Gender	8 (14%)	49 (86%)
BMI	11 (19%)	47 (81%)
Type of sport participation	10 (18%)	47 (81%)
Stress fracture/bony stress injury	43 (74%)	15 (26%)
Acute fracture	2 (3%)	56 (97%)
Other bony abnormality	4 (7%)	54 (93%)
Tendonitis	3 (5%)	55 (95%)
Other soft tissue injury	4 (7%)	54 (93%)
Concussion	4 (7%)	54 (93%)
Weight changes	28 (48%)	30 (52%)
History/report of menstrual dysfunction	44 (76%)	14 (24%)
History/report of eating disorder/disordered eating	50 (88%)	7 (12%)
Frequent/repeated injuries	27 (47%)	31 (53%)
Poor healing/lack of recovery from injury	28 (48%)	31 (52%)
Certain family history conditions	3 (5%)	55 (95%)
Screen during sports physical/PPE	23 (41%)	33 (57%)

BMI, body mass index; PPE, preparticipation physical evaluation

Table 4. Responses to the question: "What barriers do you experience when screening for RED-S and/or the Female Athlete Triad?". Respondents were allowed to select multiple options

Response	*Number (%) who responded that item was a barrier*
Lack of time with patient	34 (57%)
Lack of resources/referral sources	22 (37%)
Lack of knowledge about the conditions	8 (13%)
Lack of comfort with asking questions about the condition	6 (10%)
Patients/parents have financial barriers	7 (12%)
Fear of what screenings may reveal	1 (2%)

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Table 5. Response characteristics describing the proportion of respondents who indicated that they use specific screening tools when screening for RED-S/The Female Athlete Triad

Screening Tool	*Total Responses*	*Number (%) who responded: Yes, always*	*Number (%) who responded: Sometimes*	*Number (%) who responded: No, Never*
Sick, Control, One, Fat, Food (SCOFF) Questionnaire	52	0 (0%)	3 (6%)	49 (94%)
Disordered Eating Screen for Athletes (DESA-6)	52	0 (0%)	10 (19%)	42 (81%)
Female Athlete Screening Tool (FAST)	52	2 (4%)	14 (27%)	36 (69%)
Eating Disorder Examination Questionnaire (EDE-Q)	52	0 (0%)	4 (8%)	48 (92%)
Low Energy Available in Females Questionnaire (LEAF-Q)	54	3 (6%)	7 (13%)	44 (81%)
Brief Eating Disorder in Athletes Questionnaire (BEDA-Q)	53	1 (2%)	3 (6%)	49 (92%)
Eating Disorder Inventory (EDI)	52	0 (0%)	3 (6%)	49 (94%)
Eating Disorder Screening for Primary Care (ESP)	52	0 (0%)	1 (2%)	51 (98%)
Female Athlete Triad Risk Scale	53	4 (8%)	15 (28%)	34 (64%)
Triad Consensus Panel Screening questions	53	4 (8%)	10 (19%)	39 (74%)
Meal Attitudes and Body Weight Questions	53	3 (6%)	6 (11%)	44 (83%)
RED-S Specific Screening Tool (RST)	54	1 (2%)	14 (26%)	39 (72%)

Not all participants responded to these questions, therefore total numbers are N<60

DISCUSSION

We surveyed PRiSM members about their screening practices for RED-S/the Triad. The most important finding of this study was that, though it was not statistically significant, there was a trend toward more female health care providers screening for RED-S/the Triad than males, but the reasons for this are not fully understood. Previous studies have shown that women are more likely to receive screening for pap smears and mammograms if they see a female physician rather than a male physician.[13,14] However, it is important to note that RED-S is an issue that affects both male and female athletes. It has also been shown that female physicians have longer visits than male physicians and are more likely to have communication that is considered patient-centered.[15,16] This extra time in clinic may suggest they are spending more time asking about issues such as RED-S/the Triad. Furthermore, some male health care professionals may feel uncomfortable asking patients about menstrual history and are therefore less likely to screen.[17]

Compared to other health care professionals, orthopaedic surgeons were less likely to screen for RED-S/the Triad than other types of health care providers. This is in contrast to a previous study that showed orthopaedic surgeons had greater awareness regarding RED-S/the Triad compared to physicians in other specialties (Physical Medicine and Rehabilitation, Family Medicine, Internal Medicine, Pediatrics).[9] Although orthopaedic surgeons may have a greater awareness of these issues, our study suggests they may not be screening their patients for RED-S/the Triad risk factors. Although many issues associated with

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orthopaedic surgeon may not be directly linked to RED-S/the Triad, some high risk bone stress injuries such as femoral neck and anterior tibia may require surgery.[18,19] Thus, our findings suggests that improving screening practices requires more than just education or awareness of these conditions and should include more specific efforts regarding implementation of screening.

We found that PRiSM members use a variety of questionnaires to screen for RED-S/the Triad. The Low Energy Availability in Females Questionnaire (LEAF-Q) and Eating Disorder Examination Questionnaire (EDE-Q) are the most frequently cited in the literature as screening tools, however, we found that the FAST, Female Athlete Triad Risk Scale, the Triad Consensus Panel Screening questions, and RST were the most commonly used tools in the PRiSM respondents.[7] There are pros and cons to each screening tool. The LEAF-Q has shown to be sensitive in detecting low energy intake in adolescent athletes and, along with the EDE-Q, is one of the most frequently used tools to screen for RED-S symptoms.[7,20,21] However, it should be noted that the EDE-Q has not been validated in the adolescent athlete.[22] Because we were surveying health care professionals who are involved with both young female and male athletes, other, tools may have been more popular. Triad Consensus Panel Screening Questions are targeted toward female athletes and the Female Athlete Triad Risk Scale has limited usefulness for male athletes.[3,7] In contrast, the RST has also been found to be age-appropriate for both male and female adolescent athletes and FAST has been validated in collegiate athletes.[23,22] Despite the vast number of available screening tools, few have been tested for validity and reliability in the adolescent population. Additionally, while many of these questionnaires may be useful in identifying athletes who are intentionally engaging in restrictive eating behaviors, they may fail to reveal those who are inadvertently under-fueling due to poor nutrition management, lack of education, or lack of resources.[7] Further research should focus on validating these tools and determining the best screening tool for the adolescent population.

In addition to having a lack of consensus regarding the best screening tool for RED-S/the Triad, there were a number of other barriers to screening for RED-S/the Triad. Participants listed lack of time with patient and lack of resources as the most common barriers. Lack of time with patients is a common issue with pediatric health care professionals and has been cited as a barrier in conducting a thorough PPE.[24] Time spent on documentation and other administrative tasks has taken away from time spent with patients which limits ability to screen for RED-S/the Triad.[25,26] Furthermore, sports medicine professionals may be hesitant to screen for RED-S/the Triad if they do not have appropriate referral networks or ability to provide management plans for patients who screen positive. Thus, healthcare professionals must develop strategies for screening those athletes who may be at risk. These strategies may include encouraging athletes to return for follow up visits, scheduling longer visits, advocating their hospital systems to understand the value of screening for RED-S/the Triad, and developing referral networks for patients who screen positive for RED-S or the Triad.

Limitations

Although this study takes an important step in identifying screening patterns for RED-S/the Triad among sports medicine professionals, it does have limitations. Firstly, there was a relatively low response rate (15%), and it is possible that there was a response bias in those that chose to complete the survey. In addition, this survey only represents the practices of those practitioners involved in PRiSM, thus generalizability of these results is limited. We also were not able to normalize responses based on gender or based on type of training for specific screening tools used or for the barriers providers faced in screening. Because of the nature of cross-sectional studies, here, we are only able to evaluate associations between different demographic variables and practices, and future studies are needed to derive more causal relationships.

CONCLUSION

The negative, multi-system effects of RED-S/the Triad have been well documented.[27] It is important for healthcare providers to screen for and identify young athletes with RED-S/the Triad in order to prevent the negative long-term consequences of low energy availability. Although there is no clear gold standard for screening adolescent athletes, this study describes common screening practices among PRiSM members. We found that women were more likely to screen for RED-S/the Triad, but orthopaedic surgeons were less likely than other health care professionals to screen for RED-S/the Triad. We also identified barriers that prevent healthcare providers from

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screening for RED-S/the Triad, such as limited time and resources. Lastly, we identified the most commonly utilized tools amongst this population, including FAST and the Female Athlete Triad Risk Scale. This study takes a step towards optimizing the current and future standards for RED-S/the Triad screening amongst adolescent athletes. By describing current practices, we have identified gaps and areas of need to enhance screening for RED-S/the Triad across multiple sports medicine disciplines.

Conflict of Interest Statement

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