Distribution Agreement

In presenting this thesis as a partial fulfillment of the requirements for a degree from Emory University, I hereby grant to Emory University and its agents the non-exclusive license to archive, make accessible, and display my thesis in whole or in part in all forms of media, now or hereafter now, including display on the World Wide Web. I understand that I may select some access restrictions as part of the online submission of this thesis. I retain all ownership rights to the copyright of the thesis. I also retain the right to use in future works (such as articles or books) all or part of this thesis.

Maura Jordan Dianno April 14, 2025

Implementation of a Routine Screening of Relative Energy Deficiency Syndrome in Female Athletes

by

Maura Jordan Dianno

Dr. John Lindo
Adviser

Anthropology and Human Biology

Dr. John Lindo

Adviser

Dr. Michal Arbilly

Committee Member

Dr. Rachel Hall-Clifford

Committee Member

2025

Implementation of a Routine Screening of Relative Energy Deficiency Syndrome in Female Athletes

By

Maura Jordan Dianno

Dr. John Lindo
Adviser

An abstract of
a thesis submitted to the Faculty of Emory College of Arts and Sciences
of Emory University in partial fulfillment
of the requirements of the degree of
Bachelor of Science with Honors

Anthropology and Human Biology

2025

Abstract

Implementation of a Routine Screening of Relative Energy Deficiency Syndrome in Female Athletes

By Maura Jordan Dianno

Relative Energy Deficiency Syndrome (RED-s) can be explained as the short- and long-term health consequences of being in a continuous state of low energy availability (LEA).[1] Consequences include key bodily functions slowing down such as the reproductive system, bone health, immunity, metabolism, cardiovascular health, and psychological health. Despite notable symptoms, defined diagnosis criteria, and treatment guidelines, RED-s persists in female athlete populations, especially aesthetic and endurance sports. Additionally, athletes often seek care from multiple medical professionals such as gynecologists, sports medicine doctors, cardiologists, and gastroenterologists before RED-s is discussed.[2] Once RED-s is diagnosed however, athletes are often pulled from their sport and undergo expensive and extensive medical testing.

This paper tested the effectiveness of the implementation of a routine clinical screening athletes completed during key checkpoints of their season to monitor warning signs and habits that contribute to LEA. This would allow for earlier intervention leading to less severe consequences and less time away from the sport. Findings suggest that a screening is well accepted by a college track and field team and reflects expected trends and correlations. However, this paper also highlights the culture of college athletics, specifically track and field, and how different norms, assumptions, judgements, and knowledge gaps in women's sports contribute to the development of RED-s and the effectiveness of a clinical screening in reduction of cases.

Keywords: Relative Energy Deficiency Syndrome, Female athlete Triad, Disordered Eating, Endurance sports, Aesthetic sports

Implementation of a Routine Screening of Relative Energy Deficiency Syndrome in Female Athletes

By
Maura Jordan Dianno

Dr. John Lindo
Adviser

A thesis submitted to the Faculty of Emory College of Arts and Sciences
of Emory University in partial fulfillment
of the requirements of the degree of
Bachelor of Science with Honors

Anthropology and Human Biology

2025

Acknowledgements

Thank you to the Emory Women’s Track and Field Team, Coaches, and Medical Staff for their support and involvement in the study and the continuous support and advancement of Women's Sports.

Thank you to my advisor, Dr. John Lindo, and my committee members for helping me take on original research and a passion project.

Table of Contents

Introduction

This study aimed to test the effectiveness of the implementation of a routine, preventative screening in detecting warning signs and habits in female collegiate athletes that could potentially lead to the development of Relative Energy Deficiency syndrome (RED-s). Effectiveness of the screening was measured by feasibility, results, and impact on culture through both screening data and interviews with team members. The team consists of 56 members, including sprinters, middle- and long-distance runners, jumpers, and throwers. A total of 38 athletes filled out the first screening, 28 on the second screening, and 15 team members were interviewed over the course of a season. The primary goal of this study was to implement a routine clinical screening to all the athletes on the track and field team and compare the data to existing RED-s screenings and research in order to see if a baseline screening could identify common symptoms. Additionally, to see if the screening was sensitive enough to detect any warning signs or concerning habits on the track and field team that could lead to RED-s. In order to create an effective screening, this study aims to understand what knowledge and education the athletes, coaching staff, and medical staff have on RED-s. The last goal is to identify where gaps in care or knowledge fall short.

The two research questions this study explores are:

1. *Could a simple, self-administered screening at key parts of the athlete's season detect warning signs, symptoms, or habits that could develop into RED-s?*
2. *What cultural and social factors allow RED-s to persist in an athletic community despite the causes, symptoms, and treatments being well known?*

The focus of this study was the implementation of the new screening. Although RED-s already has developed screenings, previous developed screenings propose two major challenges:

I. Lack of accessibility, time constraints and simple measurable outcomes

Current screenings often must be hand scored and completion time ranges from 10 to 30 minutes. Some also require extensive laboratory testing and specialized doctors, which severely impact accessibility. This also places a burden on medical staff. Additionally, open ended responses allow for subjective outcomes and complicated scoring methods. To address this issue, a new screening would need to be easily accessible to *all* athletes. Questions also must be tailored in a way that minimizes subjectivity and conclusions. For example, other screenings offer scoring algorithms where higher numbers are 'bad', leading athletes to not truthfully answer questions. The proposed screening was designed with an algorithm that emphases the *change* in an individual's scoring over different parts of a season, not the score itself.

II. Timing of screening

The existing screenings are given once symptoms are noticed. However, early symptoms often mimic other medical issues. An athlete also might seek help from many different specialists who do not connect all the symptoms. Many times, the screenings have been performed too late, when medications and athletic activity have already been altered. Furthermore, athletes often fill out many screenings in a year such as a concussion testing, balance testing, illness symptoms, sleep surveys, and more. Adding this screening before symptom development could catch early onset or even habits that may lead to low energy availability.

RED-s has clear diagnostic criteria and treatment guidelines developed by the International Olympic Committee, however, 80% of female elite runners still exhibit one or more

symptoms of RED-s.[12] A new screening does not have to mean immediate treatment, but it is a tool for athletes and athletic staff to be aware of the full health picture for each athlete.

Qualitative research is also necessary to determine the feasibility of implementing a new screening. RED-s often gets associated with disordered eating and being withheld from participation in one's sport, so the screening must be trusted by the athletes so they fill it out truthfully. By adding qualitative research to discover knowledge gaps and cultural attitudes, the screening will be better adapted to the athletes and the training staff.

Literature and Context

The definition of RED-s including the driving factors, symptoms, and causes are essential to understanding the gaps in recognition, diagnosis, and treatment. Boston Children's Hospital's world renown sports medicine program defines Relative Energy Deficiency in sport as poor health and declining athletic performance due to an athlete's diet not meeting the demands of their training and daily lives.[1] Athletes are at risk if they are continually in a state of low energy availability, and without a corrective diet, this could lead to severe long term health consequences. [1] The International Olympic Committee defines RED-s as 'a syndrome of impaired physiological and/or psychological functioning experienced by female and male athletes that is caused by exposure to problematic prolonged and/or severe low energy availability.'[4] Essentially, this means an athlete is exerting more energy or calories than they are consuming per day for an extended period of time. Some of these consequences include major bodily functions being impaired or slowed down such as the reproductive system, bone health, immunity, metabolism, cardiovascular health, and psychological health.[1]

There are many known symptoms of RED-s including fatigue, rapid weight loss, missed periods, frequent illness, irritability, depression, hair loss, in addition to consequences to athletic performance.[1] In addition to an entire medical history, in the diagnosis stage, Boston Children's emphasizes an athlete's diet and attitude towards food.[1] During treatment, there is emphasis on working with a dietitian and psychologist to help address underlying nutrition and food habits.[1] With an emphasis on the correct nutrition habits, low energy availability can be corrected, lowering an athlete's risk of RED-s.[1] However, despite concrete research around RED-s being tied to low energy availability, there are still substantial cases seen in female and male athletes.

Many hospitals, sports programs, and researchers are seeking to discover where the gaps are in understanding, knowledge, and treatment. Researchers at Boston Children's propose the idea that sports that 'tie athletic success to a thin body can increase an athlete's risk of RED-s.'[1] In endurance and aesthetic sports such as track and field, there is evidence of team culture contributing significantly to RED-s including winning at all costs or achieving ideal physique.[1] Therefore, a more comprehensive dive into the motivation and factors including intrinsic and extrinsic factors are necessary to see gaps in knowledge, diagnosis, and treatment.

An article published in the Scandinavian Journal of Medicine and Science in Sports states that the true driving factors of RED-s in extreme fitness sports and sports aesthetics is not a widely studied topic, but it's well understood that the culture and type of the sport play a large role in development of low energy availability. This study published by the Scandinavian Journal of Medicine & Science in Sports followed twenty five female fitness athletes and twenty five female references and completed assessments at a baseline, two weeks (pre-competition), and one month (post-competition). The study notes that 35% of the female fitness athletes and 12% of female references reported a history of eating disorders.

The study argues that the role of fitness physique sports and the pressure of the ideal body type has a large impact on the development of RED-s.[4] Many sports that are characterized as high risk for low energy availability (gymnastics, bodybuilding, running, dance) focus on the 'athletic toned female body ideal'.[4] Furthermore, diets advertised to athletes are high-protein, low sugar, and fiber, combined with tracking of total energy and macronutrient intake allow for a slow rate of body weight loss during the seasoning which contribute to risk. Additionally, female athletes are often understudied when it comes to physical and mental health variables.

Many of the warning signs, predispositions, and risk criteria were acknowledged before the athletes went into competition season. The progression of RED-s symptoms was first observed in every female fitness athlete with the prevalence of amenorrhea increasing from 8% to 24% before the competition season started.[4] Some female fitness athletes' symptoms persisted after one month-post competition mark. The study shows the importance of surveillance on individuals at risk before competition season, and after competition. Surveillance, despite being informative, is often rare for these at-risk athletes.

A plausible explanation for why there is a lack of surveillance and early diagnosis of RED-s is that the developed criteria for screenings are complicated and lengthy. These screenings are also largely developed to be conducted after the presentation of RED-s or suspected cases. Under the investigation of RED-s, the International Olympic Committee (IOC) has developed a clinical assessment tool for use by medical professionals in diagnosing athletes with low energy availability and RED-s. The IOC RED-s CAT2 is most commonly conducted by sports medicine professionals when problematic low energy availability or RED-s is suspected. An identified issue with this assessment is the emphasis on *suspected*, which often comes when an athlete has persistent symptoms despite targeted treatment of the same symptoms.[5]

The IOC's original three step screening begins with a population-specific questionnaire. Typically, the questionnaire is only presented when an athlete presents with multiple symptoms including disordered eating, weight loss, suppressed endocrine function, etc. Additionally, it is often presented when multiple severe idiopathic clinical symptoms are present despite the questionnaire being inexpensive and easy to conduct. However, there are several shortcomings of the questionnaire itself, and why it would not be feasible to administer to all athletes..

The levels of the screening often require laboratory testing that is inaccessible to some. Additionally, the screening takes time and thorough examination from a medical professional. The threshold of administering the questionnaire is also highly critiqued due to the effects of low energy availability existing on a continuum, some being more severe and present than others, making it a judgement call by medical professionals. The original model assesses the level of risk of an athlete based on their questionnaire responses and medical history. Based on step one, step two involves more comprehensive testing including laboratory work. This model laid the groundwork for other newer assessments to hopefully correct the shortcomings of this model.

The structure of the new CAT2 Clinical assessment tool is divided by two parts. The first part is the health conceptual model which outlines the potential health consequences of RED-s. Examples of these consequences include impaired bone health, reproductive function, growth and development, and cardiovascular function, as well as mental health issues, sleep disturbances and impaired neurocognitive function. This assessment criteria was fundamental in developing a self-reported questionnaire. The second part of the CAT2 assessment includes the RED-s Performance Conceptual Model. This model includes physical indicators or RED-s in sport such as decreased power performance, decreased training response, decreased endurance performance, and decreased muscle strength. The second part of the assessment also includes mental health aspects such as decreased motivation and cognitive performance. These are all indicators that are considered during step one of the original RED-s Screening but highlighted in the CAT2. Limitations to this model include subjectivity in answers, and unmeasurable symptoms.

This article includes multiple objective signs such as weight, blood work, blood pressure, and heart rate, but also highlights many subjective considerations such as competition level, sport, motivation, endurance, etcetera. The objective and subjective aspects of diagnosis play a

large role in treatment. Treatment includes a range of approaches such as monitoring, follow-ups, modified training and/or competition, removal from training and competition, and in the most severe cases, hospitalization. The IOC's CAT2 provides a comprehensive guide to diagnosing and treating RED-s, or the early signs, low energy availability. The first step of the diagnosis involves minimally invasive evaluation of risk and is relatively low cost and accessible. However, it is a time-consuming test and usually only offered to suspected cases.

A study done by Nicolas Iragorri and Eldon Spackman on the value of these screening tools expresses how important screening tools are in preventive medicine. Additionally, it highlights the cost-effectiveness of these preventative strategies before moving to higher cost diagnostic testing.[2] As RED-s progresses, expensive diagnostic treatment such as Bone Density Scans, Electrocardiograms, Magnetic Resonance Imaging (MRIs), and extensive blood panels are often needed to diagnose and gauge the severity of RED-s. The goal of a new screening would be preventative, which is both cost effective and more beneficial to the athlete and their season.

One of the main problems identified in the study was the challenge of modeling disease progression. It defines pre-symptomatic diseases as the point in progression when the disease is developing but no symptoms are apparent.[2] This would be the gold standard for a RED-s screening, but due to the nonspecific symptoms of RED-s, the goal needs to shift to finding the distinct jump in progression of the disease by a numerical score. The time the survey hopes to hit is the sojourn time, or the interval before clinical symptoms appear and after when disease onset is identifiable by screening tools.[4] Using guidelines from the International Olympic Committee (IOC)[4], it would mean catching the progression as there is a move from 'green' or little risk to 'yellow' or mild risk.

Another problem noted in the article is non-compliance and that screening is effective only if the participants and providers are actively engaged and up to date on knowledge.[5] Common discourse on RED-s diagnosis is that the screening criteria is often very long, and diagnosis is a very long journey. The most notable screening criteria, the LEAF-Q, was developed by Anna Melin from the Department of Nutrition, Exercise and Sports Life Science at the University of Copenhagen. The LEAF-Q involves many parts with a complex scoring process which has been very beneficial in assessing risk and severity in patients with already suspected RED-s. This screening, while effective, does not contribute to the goal of catching athletes in the sojourn period. Considering these two major issues, the proposed screening in this study needs to be quick and easy for an athlete to fill out. Additionally, having a simple scoring process, simple questions, and a comparison approach where the athlete is only compared to their prior answers removes the bias of RED-s being an eating disorder and something that will end a season. It is a way to track and risk stratify to prevent long term effects.

Limitations

A major limitation of screening mechanisms is the bias and social factors surrounding RED-s. A new screening must consider how to address bias and the role of social factors in RED-s treatment, which has been a large deterrent to early diagnosis.[6] In a study by Lauren Masden, 105 female athletes were surveyed using the LEAF-Q in addition to sources of nutrition information scale (SONI scale), the group environment questionnaire (GEQ), and the revised exercise group social provisions scale (EXSPS questionnaire). This study had a goal of addressing athletes' knowledge of nutrition, exercise, and the effect of group culture on the athletes. Results showed 62.8% of participants were at risk for low energy availability and among these participants there was a significant correlation between the individuals comfort

discussing nutrition with coaches or teammates.[6] However, in this study, group cohesion, social support, and where athletes nutrition information comes from does not definitively predict or correlate to RED-s incidence.[6] The study concludes that while group cohesiveness and social support likely influences development of RED-s, it is not always the case.[6] Therefore, focusing on core, simple questions can give an accurate risk stratification for collegiate female athletes. This study does limit the role social behavior can predict RED-s, but also shows an example on how to incorporate both into a screening.

Even if a screening criteria exists, there is still a complication with treating and diagnosing RED-s. There are significant economic, social, and cultural barriers to diagnosing and accepting the diagnosis and treatment. Diagnosing too soon may lead to athletes thinking they were falsely diagnosed. Margo Mountjoy references an analogy of a red card in a soccer match, once a player obtains a red card, they are pulled from the game and do not return to play for a period of time. This journal discusses the steps to protecting athletes in a clinical setting from the 'RED-s' card. Most importantly, it brings awareness to non-invasive strategies to educate clinical staff and athletes on long energy availability and ways to mitigate their risk. Mountjoy believes that athletes often balance on a fine line between maintaining their health but while maximizing their sports performance. These doctors also caution that developing RED-s can lead to reversible and irreversible health consequences to the athlete, so it is crucial to not 'scare' athletes out of truthful answers.[7]

Another limiting factor is that RED-s has very ambiguous symptoms, but the consequences of RED-s affect many different health systems, but is not well known by specialists. For example, if an athlete has been without a menstrual cycle for extended periods of time, a Gynecologist may prescribe estrogen heavy birth control to emulate a menstrual cycle,

not addressing the root cause. Consideration should be made for diagnostic criteria before notable hormone alterations are discovered in athletes with RED-s. Many hormone changes can be reversed and improved with subtle training choices, nutrient and calorie intake, as well as addressing the root causes of low EA (energy availability) before an athlete is pulled from competition or even training.

To examine these root causes, researchers developed RED-s from the female athlete triad when it was noted that low energy availability could lead to impaired menstrual function and bone health. RED-s expands on the female athlete triad including 10 physiological and 10 performance-related effects of low EA.[8] The most detrimental effects of low energy availability including metabolic, endocrine, menstrual function, and bone health consequences, and unfortunately are not uncommon in elite female athletes.[8] More than 50% of female athletes deal with FHA or irregular menstruation.[8] The study concludes that once there is a presence of hormonal effects; it's likely the athlete already self-reported other warnings of RED-s.[8] However, in these cases, low energy availability was not considered.[8] The study recommends a more descriptive clinical explanation of RED-s instead of "low EA" which is a vague diagnosis often overlooked. Identifying how low energy availability affects endocrine pathways can better inform research, surveillance, and treatment of RED-s.[8]

A major take away from this study is 'How will it change what we do?' It argues that 'knowledge translation to stimulate desired changes in behavior is an important outcome of consensus statements'.[7] This knowledge needs to come from the athlete's ecosystem and everyone involved in their care including eating and training loads, performance goals, and an overall cultural shift towards a more sustainable physique.[7] It argues that a multifaceted approach with trainers, coaches, the athlete, and physicians can help mitigate risk of RED-s and

stop early signs in their tracks. Knowledge, screening and awareness will go a long way to improve short-term and long-term health of an athlete as well as better performance and mental state.

RED-s must be treated with a multifaceted approach including a physician, a dietician, and a psychologist in order to address all aspects of nutrition, body image, and medical consequences.[7] The danger of the multifaceted approach is LEA being conflated with an eating disorder, despite it falling on the disordered eating spectrum.[7] Although there are similarities, RED-s is not classified in the DSM-5 diagnostic tool as an eating disorder.[7] These similarities however prevent athletes from seeking treatment, even though disordered eating is suspected in 12-20% of elite female athletes.[7] This is another barrier to diagnostics and treatments that can only be addressed through cultural team changes.

Many of the symptoms overlap between RED-s and eating disorders due to the symptoms coming from the body not receiving enough calories to support all bodily functions.[9] It is an important distinction to make that not all people who have RED-s have eating disorders, and not everyone with an eating disorder develops RED-s.[9] But it is essential to consider that both diseases have symptoms that are either driven by or defined by low energy availability, which causes them to often be linked in public perception. This link would be a limitation to athletes answering screening questionnaires honestly in fear of action from training staff and coaches. Diagnosis of an eating disorder can lead to being held back from activity and treatment. Many athletes feel as if they do not fit into the category of traditional disordered eating behaviors, therefore are cautious about being honest about eating and nutrition habits.

Another major limitation of this study is compliance. The benefit to the participants may not be seen directly, but the collective benefit would be improved awareness and treatment of

RED-s for all female athletes. There could be an issue with noncompliance due to the fear of completing a screening and potentially getting pulled from participation or “accused” of disordered eating. These fears could potentially encourage people to not complete the screening or complete the screening with caution.

The final limitation of this study is time constraints. Ideally, this data would be conducted over various points of the season, even after the conclusion of the season. Due to the IRB approval process and research timeline, only two screenings were performed, three months apart. Ideally, there would be repeated studies to decide the best balance between not overloading the athlete, but being able to catch habits or symptoms early enough. An ideal schedule as per the Emory University Track and Field Program is pictured below:

Preseason:	Midseason:	Postseason:	As needed basis:
To be completed in August with physical	To be completed around the winter break point, approximately 4 months of training	To be completed at the conclusion of the semester (April), approximately 4 months after midseason	Whenever an athlete has a new injury or medical concern consistent with RED-s symptoms, compare to most recent screening

Ideal Screening Timeline for Emory Track and Field

Methods

In order to gauge if a screening would be successful among collegiate female athletes, an ethnography of the Emory University Women's Track and Field team was conducted over the course of a season. The goal of this ethnography was to understand the social, cultural and medical factors affecting the development of RED-s. Track and field athletes were chosen due to a focus on the correlation between endurance athletes, body image, and low energy availability. Additionally, the length of the season allowed for more data collection points. The ethnography consisted of two main components: interviews and a clinical screening survey.

Ethnography was utilized to gain a broader understanding of the culture surrounding RED-s, but the major objective of the study was testing the implementation of routine screening among these athletes. The success of this objective is measured by its ability to detect changes within a core set of risk factors, acceptability by athletes, and ease of completion. The screening, like many of its predecessors, were numbered, scorable questions with a few short answers. The difference is the comparison design. This survey will be filled out at different points of the season, in order to compare scores, being more efficient at screening risk factors and changes in behavior or health. This was designed so athletes could fill out the survey more honestly, and so that a streamlined screening can hold up to the sensitivity of prior screenings.

The first screening was sent out on Wednesday, September 18th to all members of the team. The second screening was sent out on Monday, January 6th. Ideally, there would be one more screening in April, but due to the time constraints of the thesis, all data was collected from these two screenings.

The screening itself is divided into different sections of the most commonly identified RED-s warning signs: Injuries, Gastrointestinal Symptoms, Menstrual Cycle, and Sleep. From

the other screenings, these are the easiest symptoms to self-assess. The goal was for student athletes to fill these out without having to track any habits or get any lab work done.

Although the main objective of the study revolves around the screening tool, RED-s is as much a product of the social environment as much as it is a physical disorder. In order for a screening to be successful, this study investigated the environment surrounding where the screening criteria would be implemented to adjust the tool to the social climate. This included conducting interviews of the target study group. A variety of interlocutors were chosen from the target group and a semi-structured interview was performed. There were four guiding questions throughout the interviews to gain a better understanding of the athlete's perception of injuries, nutrition, and rest.

1. *If you have been injured, describe the response from your coaches, trainers, doctors, and peers at the time of injury? One week later? Three weeks after?*
2. *Do you feel you were adequately educated about nutrition and rest by your coaches, trainers, doctors, and peers?*
3. *How important is diet and nutrition to you*
4. *Do you ever feel like injury was inevitable?*

In order to address non-compliance as well as assess feasibility, interviews also focused on participant's attitudes about the screening itself.

1. *What would your reaction be to a screening if your athletic trainer had you fill it out once a month? Once every three months? Would you continue to answer honestly?*
2. *When you were filling out the survey did you ever worry about retaliation like being pulled out of your sport?*
3. *Were any questions particularly hard to answer or recall?*

A crucial component of the findings was a diet analysis. This was conducted by asking multiple athletes in different event groups to track their diet for three days. Additionally, multiple event coaches were asked to describe an ideal diet for their athlete. From there, the average calories were calculated on WebMD's online calorie tracker. This was conducted to assess knowledge surrounding nutrition and further the search for gaps in knowledge, precursors, and symptoms of RED-s.

Results

Interview Findings

Perception of Injury and RED-s

Interviews were done with three primary goals: the first was understanding the perception, knowledge, and awareness of RED-s. The first team member interviewed was a 21 year old female, long distance runner. The athlete reflected on her experience with injuries and the response to being injured. In regards to nutrition, she stated the coaches feel that nutrition is essential to recovery, but often rest and nutrition is not as emphasized as cross-training and returning to running. She feels that there is a certain "team culture between injured people who have a group called 'the cross-training core'." However, injuries are divided into two groups, athletes serious about recovery and athletes not taking recovery seriously. Since there is not much coach guidance, she states athletes must "create their own brand and have the flexibility and freedom to decide your workouts." There is a distinct pressure to "run through things" or be done. Essentially, there is no one protocol that fits all athletes returning to competition, and not much guidance through the process. This can cause feelings of isolation when injured, which she claims encourages athletes to push through injuries.

Another athlete, a 22 year old sprinter, answered similar questions surrounding injuries. "You're on your own." She states that you must drive your recovery by seeking out help from the athletic training staff, talking to coaches, and returning to run without much support. She expressed that being injured is incredibly lonely and frustrating. Additionally, she stated, "track injuries are extremely frustrating because they are rarely sudden. They seem inevitable and creep

up over time, jeopardizing your season." This athlete admitted she pushed through some of the worst pain just to avoid isolation from teammates and coaches.

A 19 year old jumper shared her time being injured not as isolating, but disappointing. She felt that injuries were often seen as completely avoidable if you "do the right things" but expressed there were not clear expectations on what those things were. They felt pressure and guilt from the coaches and their teammates that their injury was their fault. The emphasis during injury was "more of a what can we do to still put hard work in and not a focus on recovery, nutrition, and injury prevention." This athlete expressed that she felt the coach or trainers did not intentionally contribute to this pressure and guilt, it was just "there."

The most prevalent finding related to injuries throughout all the interviews was that athletes are reluctant to admit and accept injury. This is likely due to team pressure, coach pressure, guilt, and fear of isolation. A culture issue that relates back to the RED-s card, and amplifies the need to identify symptoms early.

One of the interviews was with an athlete who was actually diagnosed with RED-s following multiple femoral stress fractures. She expressed that she had multiple symptoms she worked for years with doctors to resolve such as extreme bloating, irregular menstruation, and Postural orthostatic tachycardia syndrome (POTS).

"It was such an intense feeling of shame and guilt, like I did this to myself. And the worst part was, all I thought I was doing was what I was told."

She stressed that she wished there was something like a screening and more preventative meetings.

"You never expect it to be you. It was made to be something so extreme and I didn't even have an eating disorder."

This misconception is important to realizing that the prevalence of RED-s is not well understood by athletes and coaches alike, and more awareness could help cut down these misconceptions about the syndrome. One athlete expressed that she was never concerned about RED-s because she thought it was an eating disorder, and she didn't have any trouble eating. I asked a 21 year old middle-distance runner if she would have done anything differently in her college athletic career if she knew about RED-s. She expressed that she would have been way more conscious of her body's signals such as injury cues, illness, and hunger.

"I thought it was just part of the sacrifice of being a college athlete, I never thought it would cause me physical harm."

Another sprinter expressed they would have focused on a higher volume of food, and less on aesthetics if they had been aware of RED-s. This athlete explained the RED-s was mentioned one time in the beginning of the year presentation, and presented usually as "something so extreme that you are thinking, this would never happen to me."

Nutrition Knowledge Gaps

The next interviews were focused on diet and nutrition. The first overarching theme was a major concern brought up in RED-s literature: physique. Sports such as running, swimming, dance, gymnastics, and figure skating are seen as the sports with the highest prevalence of body image issues and are often regarded as "aesthetic/lean sports."[10] Many members of the team expressed that they actually ran faster when they were not "bulky" and shared that their nutrition intake on meat days was focused on whole fruit and vegetables. The idea of "bulky" leading to slower performance is a common misconception and knowledge gap seen in Track and Field.

The most overwhelming theme throughout the interviews was the lack of information. Most athletes expressed not knowing they had free nutrition counseling through student health. They shared that the only nutrition information they have access to is a once a year seminar to all athletes. The 22 year old sprinter stressed that the nutrition advice given was not applicable to everyone. Especially during travel and meet days when they are not provided with adequate nutrition by the coaches. The sprinter suggested that on long meet days where she runs many events, food is only available at inopportune time. “By the time I finished my four events, the only thing that was left was a small salad. I survived off fruit snacks and apple sauce for day one.”

The lack of food availability, quantity, and type was a common theme throughout the athletes particularly athletes with dietary restrictions or preferences. A 19 year old middle distance runner shared, “after 12 hours at a track meet, the athletic program failed to provide vegetarian options for dinner, so all I had to eat was the granola bar in my bag for a three hour bus ride home.” Many athletes claimed they wish they had nutrition education and more practical recommendations for competition days and days on campus, especially when dining options at Emory University are limited.

The 21 year old distance runner shared her experience with nutrition The main takeaways from this athlete was a lack of adequate and thorough education on nutrition. She states that she gets some education about fueling and hydration, but no guidelines of what that means. She recommended an addition to the education stating, “it would be nice if there was a recurring or meal plan idea. We usually all get in the rut of the same stuff, like an athlete's guide for Emory Resources.” Oftentimes, collegiate athletes only have access to on campus nutrition such as the dining hall and quick service options. This athlete suggested a meal plan using

Emory resources or repeat ingredients, since most athletes cook for one person. This highlighted the lack of access to *reasonable* and *attainable* nutrition advice.

A 18 year old female jumper, freshman, shared with me that she had multiple misconceptions about what her diet should look like. She believed that whole foods would keep her lean and thinner to compete better in her sport. This highlighted the increased need for education to close the gaps in knowledge. It's important to acknowledge that these needs and outcomes look different in every athlete. For one of Emory's top sprinters, their diet is packed full of carbs, healthy fats, protein, and fiber. The problem however, lies in the calories, or in RED-s terms, energy in. In addition to this athlete, I surveyed a middle distance athlete, a distance athlete, the sprints coach, middle-distance, and distance coach. The diets were very encouraging, clean, with food intake every few hours. However, the average calorie count for these diets ranged anywhere from 1,300 and 2,100 calories. The recommended calorie intake for female athletes is 2,000 to 2,400 calories a day, with recommendations up to 3,000 calories for endurance athletes.[8]

Nutrition education and a registered dietician is available to all Emory athletes. However, many of them rely on one nutrition education session a year. Many expressed that this nutrition education session is unrealistic for those eating in a dining hall, or those who are on the go constantly. In addition to nutrition education, a program must look at how it communicates the risks, symptoms, and prevalence of RED-s. It should be a constant conversation and reminder to athletes to speak up if something is not right, and to advocate for themselves.

Feasibility of Screening

From a feasibility standpoint, the last interview goal was to ask athletes how they felt about the screening itself. First was a question about the opinions on a potential required form. A 20 year old jumper reflected on the implementation of the survey.

> I think it is a good idea to have some kind of screening/check in for athletes, especially if you feel comfortable with your trainer and/or coach. I would answer honestly because I feel comfortable talking to my trainer and coach.

We talked about how a targeted check in to the issue could help athletes have access to the treatment they need, when they might not even realize the path they are headed down. A 22 year old thrower who was previously diagnosed with RED-s agreed with the screening.

> I think a screening would be a great idea and may have prevented me from developing my stress injuries. I would answer honestly. Looking back, I didn't know how much food I should be eating, what a normal menstrual cycle looks like for a runner, etc. therefore, if someone was able to view my answers and intervene, my stress injuries could have been stopped before they were developed.

This screening is not only beneficial to the health of athletes, but opens up a conversation line between athletes and their support staff to talk about RED-s, prevention, and treatment.

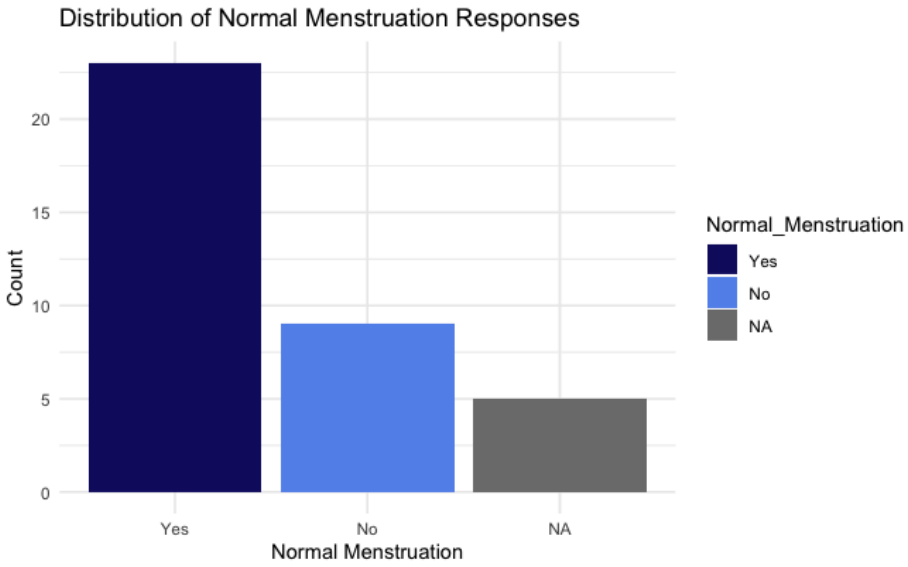
A major concern of the screening is honesty. Many athletes already conflate RED-s with an eating disorder, therefore they are hesitant to fill out the survey. Some athletes expressed that they felt the screening could be used as a 'trick' and athletes could be forced into treatment they did not want. Additionally, they are worried that filling out the screening would cause them to be pulled from their sport and risk retaliation from the coaches. The same jumper expressed "that would be in the back of my mind, as my sport is very important to me and I would not want to jeopardize my participation." To the same question, the thrower elaborated saying,

> I may worry a little bit in the case that my answers would result in me being pulled from the team. I could see how this would make me answer untruthfully, but I think for my best interest, I would still answer honestly. I may worry about feeling judged or perceived differently by coaches for how I answer. If the best thing for my health was to be pulled from competing for a bit, I would be okay with that intervention.

This led to a conversation on how although the screening could be avoided and filled out dishonestly, it is also a great tool for those who are uneducated or looking for an outlet to get help. Most athletes appreciated the screening as either a reminder or an introduction to RED-s, and expressed that they would be more mindful in the future.

Preliminary Screening Data

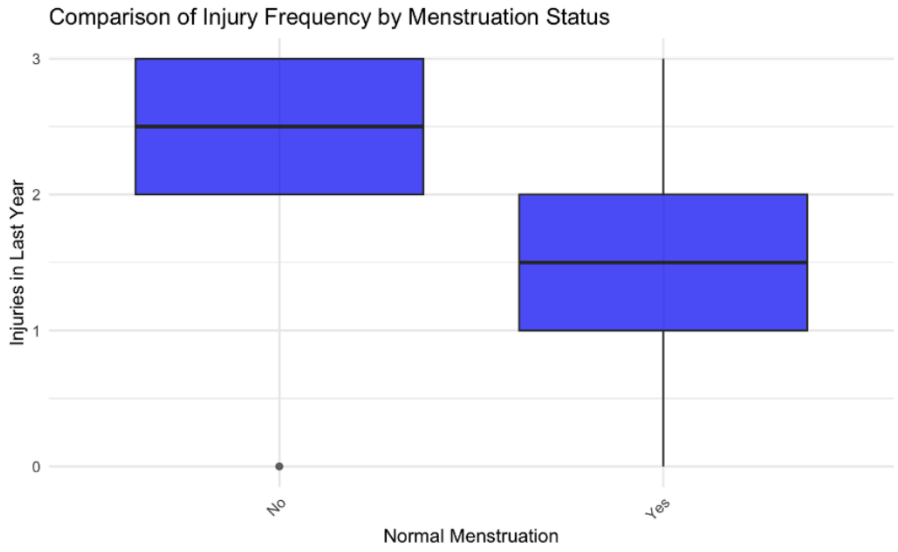
The first survey conducted in the fall semester received thirty eight responses. The screening was conducted in the middle of the cross country competition season, and approximately three weeks before the first track and field meet. From a feasibility standpoint, median completion time is 146.0 seconds and there were 38 total responses. For reference, other screenings mentioned such as the LEAFQ and RST Questionnaire take approximately eight to ten minutes to complete and additional time for a provider to score. Due to the number of responses, no statistically significant conclusions could be made, but when analyzed alone, there were certain trends discovered as "trends to watch".



Menstruation Trends Pre-Competition

The first trend is the results of normal menstruation among the athletes. Out of the 38 respondents, 28% of respondents did not have normal menstruation. Although there are many causes to irregular menstruation, almost 30% of the team warrants further investigations to factors preventing normal menstruation. Many conversations around RED-s discuss abnormal menstruation as one of the top warning signs. From interviews, many athletes felt like losing

their period was just a normal thing that happens every season. However, it also could put athletes in a different risk level for low energy availability and RED-s, especially if there are other self reported symptoms. To further investigate the severity of the risk of abnormal menstruation, menstruation status was compared against frequency of injury.

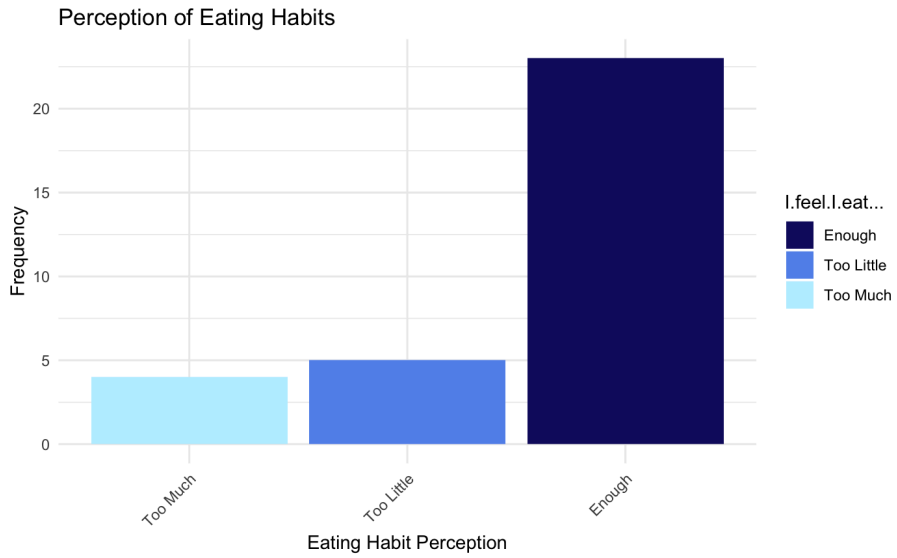


Injury Frequency versus Normal Menstruation

This result was of interest due to the correlation between normal menstruation and the number of injuries in the last year. The correlation between an athlete not having normal menstruation and a higher number of injuries shows that lack of normal menstruation could be a factor to consider when evaluating athletes' risk factors. It is important to consider that this is a correlation, because there are many medical explanations to a female not having a period, but shows promising results of the screening's sensitivity to pick up warning signs.

An additional trend identified was a behavioral trend worth exploring, especially when it comes to prevention and treatment recommendations. In participant interviews, respondents' answers about diets ranged from positive to negative. Notable trends in answers included that there were not enough resources on campus to eat full meals, and that there was not proper

guidance on how much they should be eating, therefore they do not know if they are fueling properly.

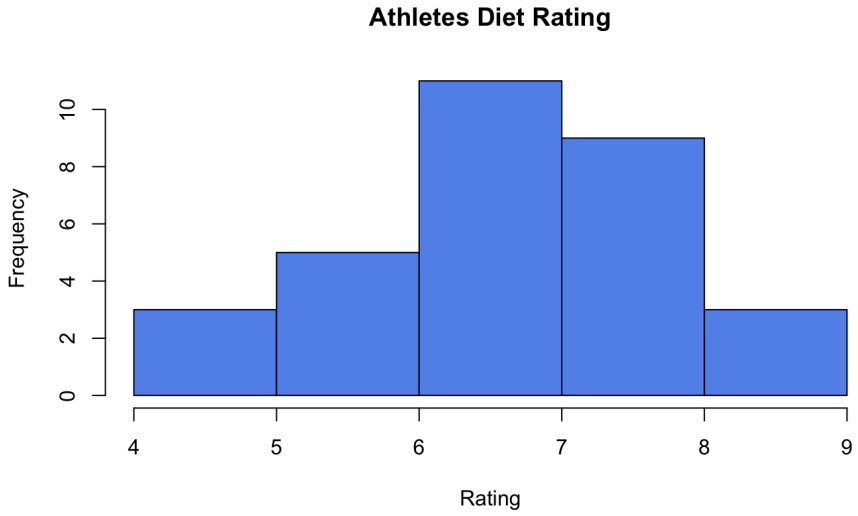


Athlete's Opinions on Their Eating Habits

However, in the first iteration of the screening, most of the participants feel like they eat enough food daily. This trend can simply highlight a knowledge gap, or is a cause for concern about the truth of the athlete's answers. Supported by interviews, many athletes are hesitant to report answers that may be seen as disordered eating or other psychological issues. Part of this fear relates to being pulled from participation, or being diagnosed with an eating disorder. Therefore, it is not surprising to see 72% of the athletes reported that they eat enough.

A new iteration of this screening may seek to ask this question in a different way to gain insight similar to interview answers.

However, when asked to rate their diet, athletes on average rated their diet a 6 to 7.



Athlete's Diet Rating

This almost contradicts above and shows that the main dietary concerns must be substance, and not amount to the athlete. This is important in understanding ways to interpret results and ask the questions on the screening itself. Many times in literature, RED-s references LEA as an amount of calories in versus out issue, but it may need to be addressed through what the athlete is eating and has access to avoid the disordered eating stigma.

Secondary Screening Data

When the screening was conducted later in the season, analysis was focused on the *change* from the first screening to the second of the individuals themselves. The first notable trend was a change in menstrual status, length and number. Six individuals changed their menstrual status between the first and second screening. One individual reported a complete cessation of their menstrual cycle. Two athletes reported fewer periods. Three individuals reported a substantial decrease in period length. Potential reasons for these changes could reflect amenorrhea or hormonal imbalances which are concerning for the development of RED-s.

Depression and anxiety levels also increased overall, potentially reflecting the stress of the season. Three athletes in the second screening changed their diet ratings to lower numbers and reported they are eating too little. This could be correlated with stress of the season, increased training demands, and raise a concern about nutrition as training increases.

In one specific individual that reported an increase in bone injuries, the athlete also had an increase in gastrointestinal issues and other injuries. This aligns with the progression of RED-s, meaning this athlete could potentially be at risk for RED-s and should be further evaluated. Another athlete who reported a cessation of her menstrual cycle also reported an increase in gastrointestinal issues. Overall, there were multiple indicators of RED-s progression both small and large. As the season progressed, athletes reported an increase in missed training and injuries, worsening bone health and injuries, increased gastrointestinal issues, and more instances of amenorrhea and other menstrual disturbances. Between the screening and the interviews, it can be assumed that as training increases, these issues also increase. Due to the small sample size, no statistically significant conclusions could be made.

Additionally, only 28 people filled out the second screening, which means 10 athletes were lost to follow up cases. A few of the athletes lost to follow up had high levels of missed training, bone injuries, and gastrointestinal issues in the first screening. Based on the interviews, there is a potential link between attrition and three major factors. One being worsening RED-s symptoms that athletes were too fearful to report at risk of being pulled from participation. Another possibility is injury related drop out where the athlete had either quit or stopped competing. Lastly, underreporting; many athletes felt like RED-s did not apply to them therefore they might not have felt the need to complete the screening. On average, those lost to follow up

had higher missed sessions, more frequent bone injuries, a higher overall injury count, and more cases of amenorrhea.

Discussion

The main focus of this study was the design and implementation of the routine clinical screening for RED-s in female track and field athletes throughout a season. The screening was designed as a comparative scoring screening; meaning athletes' answers at different points would be compared to their own answers. Due to time constraints, only two screenings were performed over the season. The screening was evaluated by feasibility, accuracy, and necessity. These were measured based on quantitative data from the survey itself in combination with literature and interviews.

The first evaluation point is feasibility. The screening sought to address a major problem with the formerly developed screening: accessibility. Many other screenings are done once RED-s is suspected, meaning there are much more thorough questions and scoring algorithms which take time from both the athlete and the medical professional to parse through. This also includes the time it takes for someone to become suspicious of RED-s and initiate the testing process. Once in this process, extensive and expensive lab work and imaging must be done to address ongoing health issues. This screening worked differently. In the first iteration of the screening, the median completion time was 146.0 seconds or a little over 2 minutes to complete. The athletes were able to complete the form on their own personal device, and it was electronically scored. This cuts out the need for one on one screening with a medical professional and instead allows medical professionals to review the results and scores online. With more development and iterations of the screening, an algorithm could be produced to highlight the highest warning criteria to cut down the time and load on the medical provider even more.

From a feasibility standpoint, it is also important to talk about the acceptance of the screening among team members. The first screening was well received with 38 responses from

the team. Interviews and trends suggested that there might be a few questions of concern that athletes did not want to fill out honestly, which would need to be addressed in future iterations. A lack of participation on the second screening, only 28 athletes, suggests fatigue and non-compliance later in the season. A limitation of this study is that participants are anonymous, there is no data on those who did not participate why. Future research could explore performing this screening in a medical setting to see if athletes are more compliant. The athletes that completed the first screening and not the second had higher warning signs of RED-s. This could suggest that athletes were apprehensive to fill out the form knowing they had concerning symptoms.

In conclusion, from a feasibility standpoint, implementing a short two minute screening at various points of the season can save an athlete from multiple unfavorable outcomes. Outcomes such as reduced participation, extensive lab work and imaging, and even severe and long-lasting health complications. A screening should be used as a baseline, not with the hopes of finding causes of concern, but being able to act early when symptoms or habits could lead to concern. Athletes undergo baseline concussion screenings every year. In a three year study done by the NCAA Injury Surveillance System (ISS), concussions accounted for 5.9% of all reported college injuries (Male and Female) and 3.9% of all high school injuries (Male and Female).[11] RED-s however, when studied in a population of athletes aged 15-32 years showed that 80% of participants demonstrated at least one symptom with 40% exhibiting at least two symptoms.[12] Baseline and continued monitoring screenings would help advise and focus treatment and prevention efforts.

The second evaluation point is accuracy. Since this study did not test the actual medical and psychological condition of the athletes, accuracy was a measure that was focused on how

well the questions were able to produce trends and relevant data. The first screening was able to identify the start of trends that the literature suggests we would see such as a correlation between menstrual cycle and injury. Also, the largest ‘cause’ of RED-s is linked to undereating, which the screening did reveal some athletes have concerning or inconsistent eating habits. Many athletes felt they were eating enough, but were not rating their diets highly. Additionally, the first screening was able to recognize warning signs of RED-s. When comparing the second screening to the first, trends showed that RED-s symptoms such as abnormal periods, gastrointestinal issues, and injuries were potentially correlated with increased bone injuries, amenorrhea, and missed training on the second screening. Combined with the interviews, there was an obvious knowledge gap between the coaches, athletes, and staff about what nutrition looks like for an athlete and access to practical and reasonable nutrition.

Lastly, the necessity of the screening. Many of the interviewees expressed they never were made aware of how severe RED-s was, how common it is, and how easy it can happen to them. This screening would be awareness and education to not only the symptoms, but be a reminder to athletes how fast things can change to be in tune with their bodies. It would be up to the trainers, the athletes, and the program if this is reasonable for their program, but combining feasibility with athlete testimony, this screening is a chance for athletes to have assistance advocating for themselves and their health.

Conclusion

This study sought to identify the effects of implementing a routine clinical screening for RED-s. The interview portion discovered that many of the athletes on the track and field were not aware of the symptoms and progression of RED-s. The screening produced some correlations and results expected from the literature, but mainly it showed the athletes and staff what symptoms to be aware of for a more timely diagnosis and treatment plan. The most common warning symptoms were bone injuries, injuries, missed training, menstrual disturbances, and gastrointestinal issues. The screening would need to be redeveloped and corrected to better identify symptoms. Additionally, loss to follow up would need to be addressed. The screening was well accepted by the team, and most interviewees were grateful and accepting of the education about RED-s and low energy availability.

As for what to do with the results of the screening, research has shown that a multifaceted approach between a sports medicine practitioner, a dietician, and a psychologist is most effective. The benefit of the study is early intervention with a multifaceted approach using a trainer, the sports team's psychologist, and the designated registered dietician. This intervention can be done while the athlete is still in full participation, to avoid missing competition and practice. It also has other benefits such as not needing as many expensive and invasive tests.

In addition to education, there needs to be more tailored nutrition information to these athletes. Blanket nutrition recommendations are confusing; students don't have access to the nutrition recommendations during the day and at competition. The types of food and the frequency of meals is not possible with limited dining options. In addition, more clear nutrition goals need to be addressed as many athletes refrain from counting calories.

Further research would include implementing this in other endurance sports to see if it produces the same results. If it was repeated at different Universities, there might be different findings based on coaching, training, food availability, and other confounding variables. Overall, there is no risk to athletes by completing this screening. It takes less time than a concussion screening conducted yearly, and less time than yearly physicals and paperwork. Implementing a routine clinical study could bring awareness to the athlete and staff about potential health issues, aid in more comprehensive health care, and give the athletes a stronger voice.

Bibliography

1. Wu Tsai Female Athlete Program. Relative Energy Deficiency in Sport (REDs) | Boston Children's Hospital. Accessed February 26, 2025. https://www.childrenshospital.org/conditions/reds

2. Iragorri N, Spackman E. Assessing the value of screening tools: reviewing the challenges and opportunities of cost-effectiveness analysis. *Public Health Reviews*. 2018;39(1):17. doi:10.1186/s40985-018-0093-8

3. Dave SC, Fisher M. Relative energy deficiency in sport (RED – S). *Current Problems in Pediatric and Adolescent Health Care*. 2022;52(8):101242. doi:10.1016/j.cppeds.2022.101242

4. Mathisen T, Heia J, Raustol M, Sandeggen M, Fjellestad I, Sundgot-Borgen J. Physical health and symptoms of relative energy deficiency in female fitness athletes - Mathisen - 2020 - Scandinavian Journal of Medicine & Science in Sports - Wiley Online Library. Accessed February 26, 2025. https://onlinelibrary.wiley.com/doi/10.1111/sms.13568

5. Terry A, Szabo A, Griffiths M. The Exercise Addiction Inventory: A New Brief Screening Tool. *Addiction Research & Theory*. 2004;12(5):489-499. doi:10.1080/16066350310001637363

6. Masden L, Tripure A, Mahoney S. The Role of Social Factors in Relative Energy Deficiency Risk for Female Collegiate Athletes. *Journal of Women's Sports Medicine*. 2023;3(3):30-38. doi:10.53646/jkm6yw15

7. Mountjoy M, Ackerman KE, Bailey DM, et al. Avoiding the 'REDs Card'. We all have a role in the mitigation of REDs in athletes. *Br J Sports Med*. 2023;57(17):1063. doi:10.1136/bjsports-2023-106749

8. Elliott-Sale KJ, Tenforde AS, Parziale AL, Holtzman B, Ackerman KE. Endocrine Effects of Relative Energy Deficiency in Sport. Published online July 1, 2018. doi:10.1123/ijsnem.2018-0127

9. Hellner. Understanding RED-S Syndrome and Eating Disorders. July 3, 2023. Accessed February 26, 2025. https://equip.health/articles/food-and-fitness/red-s-syndrome-relative-energy-deficiency-in-sport

10. Burgon RH, Beard J, Waller G. Body image concerns across different sports and sporting levels: A systematic review and meta-analysis. *Body Image*. 2023;46:9-31. doi:10.1016/j.bodyim.2023.04.007

11. Covassin T, Swanik CB, Sachs ML. Sex Differences and the Incidence of Concussions Among Collegiate Athletes. *J Athl Train*. 2003;38(3):238-244.

12. Witkoś J, Błażejewski G, Gierach M. The Low Energy Availability in Females Questionnaire (LEAF-Q) as a Useful Tool to Identify Female Triathletes at Risk for Menstrual Disorders Related to Low Energy Availability. *Nutrients*. 2023;15(3):650. doi:10.3390/nu15030650

13. Davelaar CMF, Ostrom M, Schulz J, Trane K, Wolkin A, Granger J. Validation of an Age-Appropriate Screening Tool for Female Athlete Triad and Relative Energy Deficiency in Sport in Young Athletes | Cureus. Accessed February 26, 2025. https://www.cureus.com/articles/30734-validation-of-an-age-appropriate-screening-tool-for-female-athlete-triad-and-relative-energy-deficiency-in-sport-in-young-athletes#!/

Appendix

IRB Information

STUDY00007903 was approved by the Institutional Review Board at Emory University by an Expedited Approval on September 18th, 2024. All data, transcripts, and notes were stored on Emory Onedrive and will be deleted upon my graduation from Emory University in May 2025. Data will not be shared in the publication process. All participants completed the survey using their Emory 7 digit ID numbers. No names were collected in the process. For recruitment, emails were sent to the coaching staff and directly to the all athletes on the team via groupme channels and email.

IRB EXPEDITED APPROVAL

September 18, 2024

John Lindo, PhD

jlindo@emory.edu

Title:	Effectiveness of the Implementation of Routine Screening of Relative Energy Deficiency Syndrome in Female Athletes
Principal Investigator:	John Lindo
IRB ID:	STUDY00007903
Funding:	None
Documents Reviewed:	• Consent Form, Category: Consent Form; • Interview Questions Guide, Category: Surveys, Questionnaires, Interview Guides; • IRB Protocol, Category: IRB Protocol; • Recruitment Email, Category: Recruitment Materials; • Survey File, Category: Surveys, Questionnaires, Interview Guides; • Waiver of Consent, Category: Other site-related documents not attached on previous forms;

Dear Dr. John Lindo:

On 9/18/2024 the Emory IRB reviewed the above-referenced study by expedited process. This research is eligible for expedited review under 45 CFR.46.110 and/or 21 CFR 56.110 because it poses minimal risk and fits expedited review categories F[4, 7] as set forth in the Federal Register.

No annual IRB review is required, as permitted under the 2018 Common Rule.

Please note carefully the following items with respect to this approval:

- To document consent, use the consent documents that were approved and stamped by the IRB. Go to the Documents tab to download them.

Screening Consent Form

Emory University
Oral Consent Script
For a Research Study

Title: Effectiveness of the Implementation of Routine Screening of Relative Energy Deficiency Syndrome in Female Athletes

IRB #: 00007903
Principal Investigator: Dr. John Lindo

Study-Supporter: Maura Dianno

Introduction and Study Overview

Thank you for your interest in our Relative Energy Deficiency study. We would like to tell you what you need to think about before you choose whether or not to join the study. It is your choice. If you choose to join, you can change your mind later on and leave the study.

The purpose of this study is examining the trends in Relative Energy Deficiency symptoms throughout an athlete's season. The study is an honors thesis through the undergraduate Anthropology department. This survey will take about 5 minutes to complete. The interview portion will be approximately 25 minutes. The physical testing will take 20 minutes to complete.

If you join, during the survey portion you will be asked a series of questions about your overall health and well-being via an electronic survey. The interview portion will be a series of questions about your experience as an athlete, team culture, and knowledge of nutrition. The physical testing includes being weighted, having blood pressure and heart rate recorded via electronic cuff, and a series of concentration and reaction time games.

The survey, interview, and physical testing include potentially sensitive questions about body image, and mental health. The survey and physical testing also have a very minor risk of eye strain. A breach of confidentiality is a potential risk of participating in this study.

You may not benefit from joining the study. his study is designed to learn more about the indicators of Relative Energy Deficiency and the ability to catch the progression of the syndrome early on. The study results may be used to help others in the future.

Storing and Sharing your Information
We will store all the data that you provide using your unique seven-digit code. We need this code so that we can keep track of your data over time. This code will not include information that can identify you (identifiers). Specifically, it will not include your name, initials, date of birth, or medical record number. We will keep a file that links this code to your identifiers in a secure location separate from the data.

We will not allow your name and any other fact that might point to you to appear when we present or publish the results of this study.

Your data may be useful for other research being done by investigators at Emory or elsewhere. We may share the data linked by the study code, with other researchers at Emory or with researchers at other institutions that maintain at least the same level of data security that we maintain at Emory We will not share the link between the study code and your identity.

Confidentiality

Certain offices and people other than the researchers may look at study records. Government agencies and Emory employees overseeing proper study conduct may look at your study records. These offices include the Office for Human Research Protections and the Emory Institutional Review Board. Study funders may also look at your study records. Emory will keep any research records we create private to the extent we are required to do so by law. A study number rather than your name will be used on study records wherever possible. Your name and other facts that might point to you will not appear when we present this study or publish its results.

People Who will Use/Disclose Your Information:

The following people and groups will use and disclose your information in connection with the research study:

- The Principal Investigator and the research staff will use and disclose your information to conduct the study.
- Emory may use and disclose your information.
- The Principal Investigator and research staff will share your information with other people and groups to help conduct the study or to provide oversight for the study.
- The following people and groups will use your information to make sure the research is done correctly and safely:
    - Emory offices that are part of the Human Research Participant Protection Program and those that are involved in study administration and billing. These include the Emory IRB, the Emory Research and Healthcare Compliance Offices, and the Emory Office for Clinical Research.
    - Government agencies that regulate the research including Office for Human Research Protections
    - Public health agencies.
    - Research monitors and reviewer.
    - Accreditation agencies.
- Sometimes a Principal Investigator or other researcher moves to a different institution. If this happens, your information may be shared with that new institution and their oversight offices. Information will be shared securely and under a legal agreement to ensure it continues to be used under the terms of this consent.

Contact Information

If you have questions about the study procedures, appointments, research-related injuries or bad reactions, or other questions or concerns about the research or your part in it, contact Maura Dianno at maura.dianno@emory.edu or 267-788-3844

This study has been reviewed by an ethics committee to ensure the protection of research participants. If you have questions about your **rights as a research participant**, or if you have **complaints** about the research or an issue you would rather discuss with someone outside the research team, contact the Emory Institutional Review Board at 404-712-0720 or 877-503-9797 or irb@emory.edu.

Screening Survey

EMORY UNIVERSITY

Information

This is a survey designed to collect data on your risk level of developing Relative Energy Deficiency Syndrome at different points during the year. All results will not contain identifiable information for personal privacy. You are welcome to stop this questionnaire at any time. Please contact me with any concerns: maura.dianno@emory.edu

There are minimal risks with this survey including possible triggering questions causing emotional upset or distress.

Please enter your 7 digit Emory University ID number. This will be in place of a name or email in order to not collect identifable information.

** Please remember this number as you will need it again later

Injuries

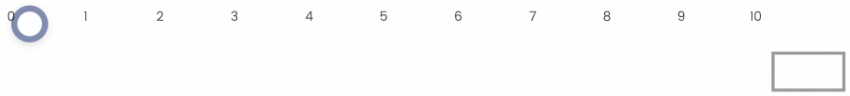
I feel injuries have effected multiple days of my training.

0 - Very Few (1-4 Days) 10 - Very Many (22 Days or More)

0 1 2 3 4 5 6 7 8 9 10

I have had _ _ _ bone injuries in the last calendar year.

I have had _ _ _ other injuries in the last calendar year.



Gastrointestinal Symptoms

How many days per weeks do you experience unexplained gas, bloating, constipation, or diarrhea?

Menstrual Function

Do you have normal menstruation (every 28-34 days)?

- Yes
- No

Are you on hormonal contraceptives?

- Yes
- No

If yes, what type of contraceptives (Pill, IUD, Ring)

Approximately, how many periods have you had in the last calendar year?

On average, how many days do you bleed during your menstrual cycle?

Not Applicable

0 1 2 3 4 5 6 7 8 9 10

Has your menstrual cycle ever stopped for 3 months or more?

- Yes
- No

Sleep

On average, how many hours of sleep do you get per night?

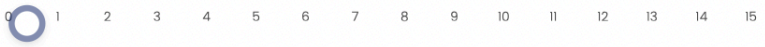
0 1 2 3 4 5 6 7 8 9 10

On average, how many times do you wake up per night?

0 1 2 3 4 5 6 7 8 9 10

Immunity

Approximately, how many times were you sick in the past calendar year?



Diet

Rate your current diet.

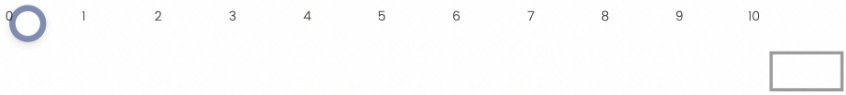
I feel I eat...

- Too Little
- Enough
- Too Much

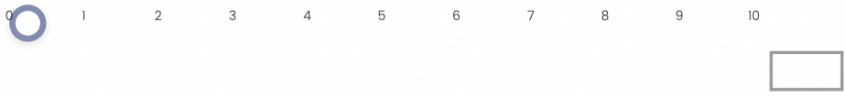
Mental Health

On average, how anxious do you feel throughout the day?

On average, how depressed do you feel throughout the day?



How happy are you with your current body?



Office of Institutional Research and Decision Support
oir@emory.edu

LEAFQ Questionnaire[12]

(Supplemental Digital Content 1)

The LEAF-Q

A questionnaire for female athletes

Department of Sport Science
Linnaeus University
Sweden
Contact: Anna Melin, anna.melin@lnu.se

The low energy availability in females questionnaire (LEAF –Q), focuses on physiological symptoms of insufficient energy intake. The following pages contain questions regarding injuries, gastrointestinal and reproductive function. We appreciate you taking the time to fill out the LEAF-Q and the reply will be treated as confidential.

Name: _____

Address: _____

E-mail: _____

Cell phone: _____

Sport: _____

- How old were you when you began to specialize in your sport?:_____ age
- What level of athlete are you?
  Club ☐
  National team ☐
  Professional ☐
  Other ☐
- Are you a full-time athlete? Yes ☐ No ☐
- If not, what occupation do you have beside your sport?
  Full time job ☐
  Part time job ☐
  Student ☐
  Other ☐
- What is your maximal oxygen consumption (Vo_2max)?

  _____ml/kg/min or

  _____l/min

  I do not know/I have never measured it ☐

- Your best results at World Championship, Olympic Games or World Cup?
  1st to 3rd place ☐
  4th to 6th place ☐
  7th to 10th place ☐
  11th place or lower ☐
  I have never competed at this level ☐
  I don't remember ☐

- Your normal amount of training in the preparation or basic period (not competition) on **average per month:**

  _____ hours/month

- Age: _____(years)

- Height: _____(cm)

- Present weight: _____(kg)

- Your highest weight with your present height: _____ (kg)

- Your lowest weight with your present height: _____ (kg)

- What is your preferred body weight during competition? _____ (kg)

- What is your body fat percentage (if it has been measured)? _____ (%)

- Chronic illness (e.g. diabetes, Crohn's Disease)?
  Yes ☐ No ☐

  If yes, which one (s)?

- Food allergy or intolerance (e.g. nut allergy, celiac disease, lactose intolerance)?
  Yes ☐ No ☐

  If yes, which one (s)?

---

1. Injuries **Mark the response that most accurately describes your situation**

A: Have you had absences from your training, or participation in competitions during the last year due to injuries?

☐ No, not at all ☐ Yes, once or twice ☐ Yes, three or four times ☐ Yes, five times or more

A1: If yes, for how many days absence from training or participation in competition due to injuries have you had in the last year?

☐ 1-7 days ☐ 8-14 days ☐ 15-21 days ☐ 22 days or more

A2.1: If yes, have you had a bone stress injury? Yes ☐ No ☐

If yes, specify how many _____

Specify the location(s): femoral neck ☐ total hip ☐ sacrum ☐ pelvis ☐ other site(s) ☐

A2.2: If yes, have you had other types over load injuries? Yes ☐ No ☐

If yes, specify how many and location?_____

A2.3: If yes, have you had an acute injury? Yes ☐ No ☐

If yes, specify how many and location?_____

2. Gastro intestinal function

A: Do you feel gaseous or bloated in the abdomen, also when you do not have your period?

☐ Yes, several times a day ☐ Yes, several times a week

☐ Yes, once or twice a week or more seldom ☐ Rarely or never

B: Do you get cramps or stomach ache which cannot be related to your menstruation?

☐ Yes, several times a day ☐ Yes, several times a week

☐ Yes, once or twice a week or more seldom ☐ Rarely or never

C: How often do you have bowel movements on average?

☐ Several times a day ☐ Once a day ☐ Every second day

☐ Twice a week ☐ Once a week or more rarely

D: How would you describe your normal stool?

☐ Normal (soft) ☐ Diarrhoea-like (watery) ☐ Hard and dry

Comments regarding gastrointestinal function: _____

3. Menstrual function and use of contraceptives

3.1 Contraceptives

Mark the response that most accurately describes your situation

A: Do you use oral contraceptives?

☐ Yes ☐ No

A1: If yes, why do you use oral contraceptives?

☐ Contraception ☐ Reduction of menstruation pains ☐ Reduction of bleeding

☐ To regulate the menstrual cycle in relation to performances etc..

☐ Otherwise menstruation stops

☐ Other_____

_____

A2: If no, have you used oral contraceptives earlier?

☐ Yes ☐ No

A2:1 If yes, when and for how long?_____

_____

_____

B: Do you use any other kind of hormonal contraceptives? (e.g. hormonal implant or coil)

☐ Yes ☐ No

B1: If yes, what kind?

☐ Hormonal patches ☐ Hormonal ring ☐ Hormonal coil ☐ Hormonal implant ☐ Other

_____

3.2 Menstrual function **Mark the response that most accurately describes your situation**

A: How old were when you had your first period?

☐ 11 years or younger ☐ 12-14 years ☐ 15 years or older ☐ I don't remember

☐ I have never menstruated (If you have answered "I have never menstruated" there are no further questions to answer)

B: Did your first menstruation come naturally (by itself)?

☐ Yes ☐ No ☐ I don't remember

B1: If no, what kind of treatment was used to start your menstrual cycle?

☐ Hormonal treatment ☐ Weight gain

☐ Reduced amount of exercise ☐ Other

C: Do you have normal menstruation?

☐ Yes ☐ No **(go to question C6)** ☐ I don't know **(go to question C6)**

C1: If yes, when was your last period?

☐ 0-4 weeks ago ☐ 1-2 months ago ☐ 3-4 months ago ☐ 5-6 months ago ☐ more than 6 months ago ☐ 12 months ago or more

C2: If yes, are your periods regular? (Every 28th to 34th day)

☐ Yes, most of the time ☐ No, mostly not

C3: If yes, for how many days do you normally bleed?

☐ 1-2 days ☐ 3-4 days ☐ 5-6 days ☐ 7-8 days ☐ 9 days or more

C4: If yes, have you ever had problems with heavy menstrual bleeding?

☐ Yes ☐ No

C5: If yes, how many periods have you had during the last year?

☐ 12 or more ☐ 9-11 ☐ 6-8 ☐ 3-5 ☐ 0-2

3.2 Menstrual function **Mark the response that most accurately describes your situation**

C6: If no or "I don't remember", when did you have your last period?

☐ 1-2 months ago ☐ 3-4 months ago ☐ 5-6 months ago

☐ ☐ more than 6 months ago ☐ 12 months ago or more

☐ I'm pregnant and therefore do not

D: Have your periods ever stopped for 3 consecutive months or longer (besides pregnancy)?

☐ No, never ☐ Yes, it has happened before ☐ Yes, that's the situation now

---

E: Do you experience that your menstruation changes when you increase your exercise intensity, frequency or duration?

☐ Yes ☐ No

E1: If yes, how? (Check one or more options)

☐ I bleed less ☐ I bleed fewer days ☐ My menstruations stops

☐ I bleed more ☐ I bleed more days

RST Questionnaire[13]

Relative Energy Deficiency in Sports (RED-S) Survey
For Female Participants Only

Instructions: Please thoroughly read each question before answering. Answer as honestly as possible. Remember, only the research team will be reading your answers.

Age: _____ Years old
How tall are you? _____Feet _____ Inches
How much do you weigh? _____ Pounds

1) Have you recently had a change in your weight? ( ) No ( ) Yes, lost ( ) Yes, gained

2) Have you been told you have anemia? ( ) Yes ( ) No ( ) Not Sure

3) Have you noticed a change in your skin color? ( ) Yes ( ) No
If yes, what were the changes? _____
_____

4) Do you play any sport(s) or do any physical activity (playing outside, recess, P.E. class, playing with your brother/sister/or friends)? ( ) Yes ( ) No

If so, what do you do? _____
_____
_____

	0 - 1 hours	1 - 2 hours	2 - 5 hours	5 + hours
5) How many hours of physical activity do you do every day?				

	0 - 2 days/week	2 - 3 days/week	3 - 5 days/week	6 - 7 days/week
6) How many times in a week do you play/do your sport/activity?				

7) Have you felt like you were going to faint? ( ) Yes ( ) No

	Yes	No
8) Do you feel like your ability to perform your sport has changed? (Example: I feel awkward, weak, can't play as long as I used to)		

	Always	Usually	Sometimes	Rarely	Never
9) Are you terrified about being overweight?					

10) Have you been more tired recently? ( ) Yes ( ) No

11) How old were you when you first got your period? _____Years old

12) How many days does your period last? _____Days

	More than once a month	Once a month	Once every 1 - 3 months	Less than every 3 months
13) How often do you get your period?				

14) Have you gone more than 3 months without your period before? ( ) Yes ( ) No

	My period does not influence me	Not during my period	Right before my period	During my period	Right after my period	About 15 days after my period
15) If you could choose a time to compete or practice, you would choose: *(You can pick more than one answer)*						

16) Are you prescribed any medication to help with your period or your hormones?
( ) Yes ( ) No

	Always	Usually	Sometimes	Rarely	Never
17) Are you worried about what you eat?					

	Always	Usually	Sometimes	Rarely	Never
18) Do you feel like you can't stop eating, even if you feel full?					

19A) Have you ever had a stress fracture? (Example: didn't happen while falling down, getting in an accident, accidentally running into someone or something) ( ) Yes ( ) No

If you answered "Yes" to 19A, please answer 19B- D:

	0 - 1 hours/day	1 - 2 hours / day	2 - 5 hours / day	5+ hours/day
19B) How much activity (hours/day) were you doing at the time of your injury?				

	0 - 2 days/week	2-3 days/ week	3 - 5 days/week	6 - 7 days/week
19C) How much activity (days/week) were you doing at the time of your injury?				

19D) When you had the fracture, were you getting your period?
( ) Yes ( ) No ( ) I don't remember

	Always	Usually	Sometimes	Rarely	Never
20) Have you purposely thrown up after eating?					

21) Have you had a fever/infection in the last 6 months? ( )Yes ( ) No
If yes, when did your fever start? _____
If yes, is your fever gone now? ( ) Yes ( ) No

	Always	Usually	Sometimes	Rarely	Never
22) How often do you drink milk (any type)?					

	Always	Usually	Sometimes	Rarely	Never
23) Do you feel extremely guilty after eating?					

24) Do you take calcium supplements? ( ) Yes ( ) No

	Always	Usually	Sometimes	Rarely	Never
25) Do you wish you were thinner?					

26) Check the following feelings that you've felt over the last 6 months:

	Yes	No
Easily annoyed		
Sad all the time		
Hard to focus		
Hard for me to make decisions		
Stressed		
Nervous		

	Always	Usually	Sometimes	Rarely	Never
27) Do you think about burning calories while exercising?					

28) Do you have a heart condition? ( ) Yes ( ) No

	Always	Usually	Sometimes	Rarely	Never
29) Are you worried with the thought of having fat on your body?					
30) Do you feel pressured by your friends, parents, or coaches to lose weight?.					

31) What, if any, type of diet do you eat? Check all that apply:

( ) No Special Diet ( ) Gluten Free ( ) Dairy-Free ( ) Vegetarian
( ) Vegan ( ) Nut-free ( ) Paleo ( ) Low-fat
( ) High-protein ( ) Low- Sugar ( ) Low-Carb

Is the diet you selected above due to choice or allergy? ( ) Choice ( ) Allergy

IOC CAT 2 Diagnostic Criteria[4]

What is the IOC REDs CAT2?

The IOC REDs CAT2 is a clinical assessment tool for the evaluation of athletes/active individuals suspected of having problematic low energy availability (LEA) leading to REDs and for guiding the determination of level of sport participation. The IOC REDs CAT2 is designed for use by athlete health and performance teams, led by a physician, in the clinical evaluation and management of athletes with this syndrome. The IOC REDs CAT2 is based on the 2023 IOC REDs Consensus Statement[1], replacing the original RED-S CAT[2]. For more details on the development, underpinning science, and validation process, please see the IOC REDs CAT publication in the 2023 British Journal of Sports Medicine (BJSM) REDs dedicated edition[3].

This tool may be freely copied and translated in its current form for use by the athlete health and performance team. We encourage sports organisations, as well as sports medicine physicians to implement the various steps of the tool into their athlete health screening, diagnosis, and treatment policies. Alterations to the tool or reproduction for publication purposes require permission from the IOC and BJSM.

Note: *The diagnosis of REDs is a medical diagnosis to be made by a sports medicine physician. Clinical treatment of athletes with REDs should be implemented by an experienced, multidisciplinary athlete health and performance team.*

What is REDs?

REDs is defined as:

A syndrome of impaired physiological and/or psychological functioning experienced by female and male athletes that is caused by exposure to problematic (prolonged and/or severe) low energy availability. The detrimental outcomes include but are not limited to decreases in metabolic function, reproductive function, musculoskeletal health, immunity, glycogen synthesis, cardiovascular and haematological health, which can all individually and synergistically lead to impaired well-being, increased injury risk, and decreased sports performance[1].

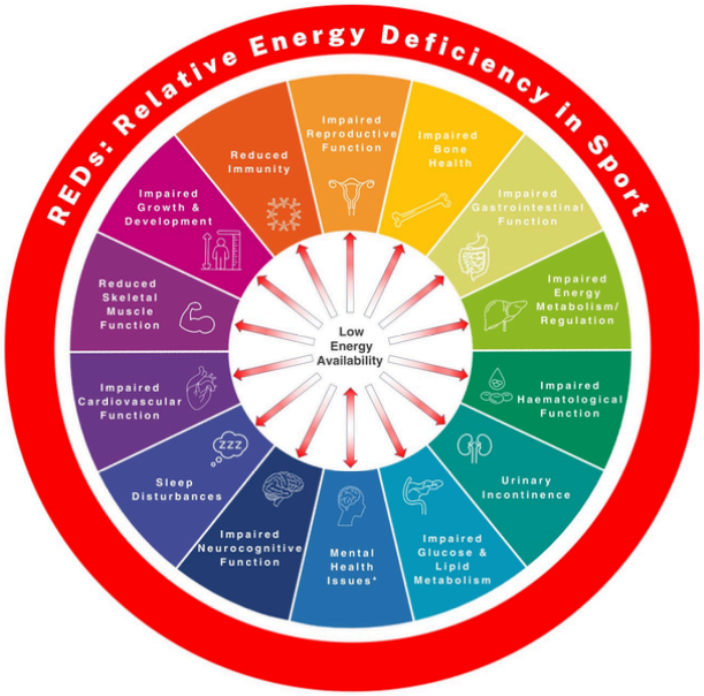
The cause of REDs is the clinical syndrome that results from exposure to problematic LEA where an individual's dietary energy intake is insufficient to support the energy expenditure required for health, function, and daily living once the cost of exercise and sporting activities is taken into account.

The formula representing this is:

$$EA = \frac{\text{energy intake (EI) (kcal)} - \text{exercise energy expenditure (EEE) (kcal)}}{\text{FFM (kg)}} \text{ per day}^{-1}$$

REDs Health Conceptual Model

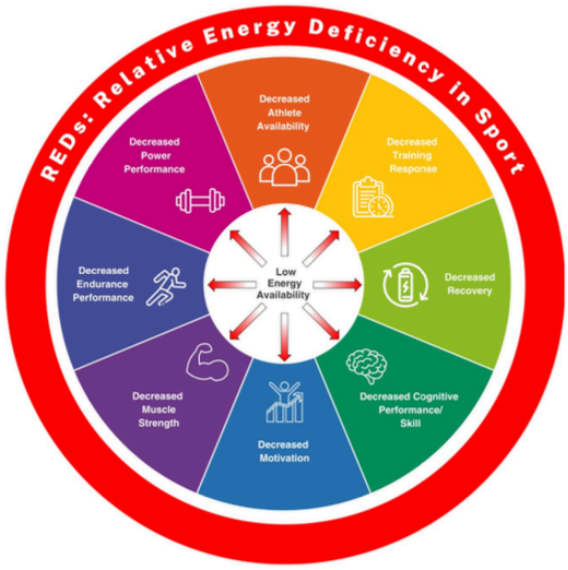
The potential health consequences of REDs are depicted in the REDs health conceptual model. Psychological problems can be both the result of and/or the cause of REDs (*)



REDs Health Conceptual Model
The effects of LEA exist on a continuum. While some level of exposure to LEA is mild and transient, termed adaptable LEA (arrow depicted in white), problematic LEA is associated with a variety of adverse REDs outcomes (arrow depicted in red).

REDs Performance Conceptual Model

REDs may also affect athlete sports performance. The potential effects of REDs on sports performance are illustrated in the following model:

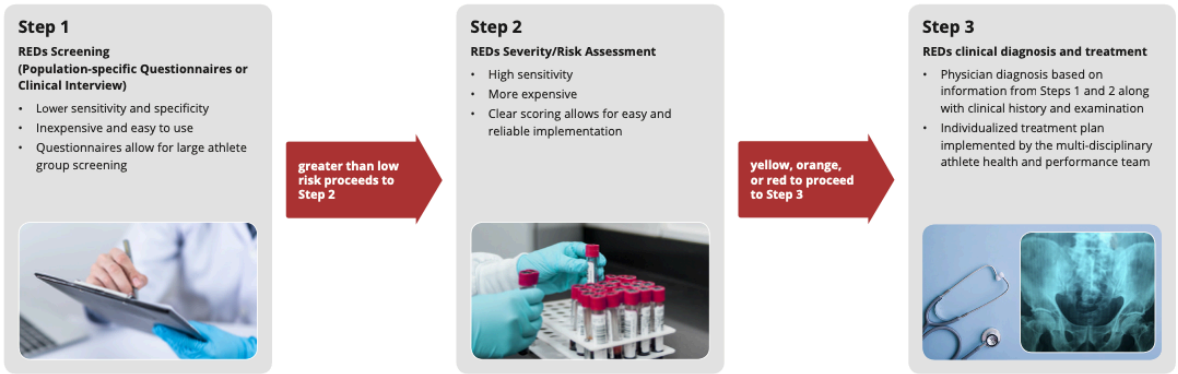


REDs Performance Conceptual Model
The effects of LEA exist on a continuum. While some level of exposure to LEA is mild and transient, termed adaptable LEA (arrow depicted in white), problematic LEA is associated with a variety of adverse REDs outcomes (arrow depicted in red).

IOC REDs CAT2 Three Step Model

The screening and diagnosis of REDs is challenging, as symptomatology can be subtle and further complicated by the diverse list of potential differential diagnoses; as well, the measurement of energy availability and exercise expenditure is fraught with challenges. A special focus on the athlete at risk is needed. Although any athlete or active individual can suffer from REDs, those at particular risk are female athletes, those in weight-sensitive and leanness-demanding sports, including but not limited to weight class sports (e.g., combat disciplines), aesthetically judged sports (e.g., gymnastics disciplines), sports in which a low body weight might provide a performance advantage (e.g., anti-gravity disciplines, such as high jump), and in sports with high exercise energy expenditure (e.g., endurance disciplines). Detection through self-reported and/or objective screening is important to identify an athlete at risk for REDs early, providing an opportunity to intervene promptly to maintain and improve performance and prevent long-term health consequences.

The IOC REDs CAT2 is a three-step model



Step 1) REDs Screening: initial screening using population-specific questionnaires assessing the presence of REDs indicators or clinical interviewing. Athletes deemed at risk for REDs based on Step 1 should complete ***Step 2)*** REDs Severity/Risk Assessment (see Table below) and Stratification and Sports Participation Guidelines (see REDs Stratification and Sports Participation Guidelines Figure below). Collected clinical data from Step 2 informs ***Step 3)*** a sports medicine physician-led clinical diagnosis and the implementation of a individualised treatment plan, ideally integrating a collaborative multi-disciplinary REDs health and performance team.

Step 1: Screening for REDs

Screening for REDs using a population-specific, REDs-related questionnaire or clinical interview can be undertaken as part of an annual periodic health examination and when an athlete presents with Disordered Eating (DE)/Eating Disorders (ED), weight loss and/or fluctuations, lack of normal growth and development, endocrine dysfunction, recurrent injuries and illnesses, bone stress injury, decreased performance/performance variability or mood changes. As with all self-reported symptom screening tools, sensitivity and validity can be challenging[4], but they are inexpensive and scalable for large athlete populations. Depending on the athlete-population, and typical symptoms, initial screening tools for consideration include:

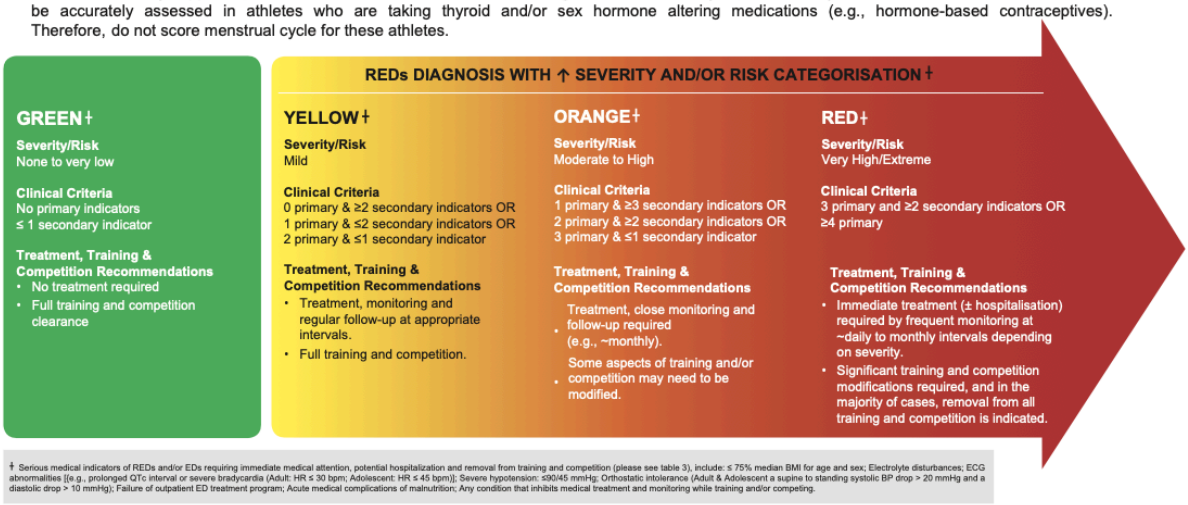
- LEAF-Q (Low Energy Availability in Females Questionnaire) [5]
  https://bjsm.bmj.com/content/bjsports/suppl/2014/02/21/bjsports-2013-093240.DC1/bjsports-2013-093240supp1.pdf
  LEAF-Q Scoring Guide:
  https://bjsm.bmj.com/content/bjsports/suppl/2014/02/21/bjsports-2013-093240.DC1/bjsports-2013-093240supp2.pdf
- LEAM-Q (Low Energy Availability in Males Questionnaire) [6]
  https://www.mdpi.com/2072-6643/14/9/1873 (see supplementary material)
- RST (RED-S Specific Screening Tool) [7]
  https://assets.cureus.com/uploads/original_article/pdf/30734/1612430181-1612430175-20210204-18268-i9k6n7.pdf
  (Questionnaire in appendix C, scoring guide in appendix B)
- SEAQ-I (Sport-Specific Energy Availability Questionnaire and Interview) [8]
  https://bmjopensem.bmj.com/content/4/1/e000424
  (see supplementary material)
- EDE-Q (Eating Disorder Examination Questionnaire) [9]
  https://socialwork.buffalo.edu/content/dam/socialwork/continuing-education/documents/Eating-Questionairre-EDE-Q.pdf
- SCOFF (Sick, Control, One (stone), Fat, and Food Questionnaire) [10]
  https://www.nutritionhealth.com.au/site/assets/files/1064/scoff-questionnaire.pdf
- EAI (Exercise Addiction Inventory) [11]
  https://doi.org/10.1080/16066350310001637363 (see appendix 1)
- EDS (Exercise Dependence Scale) [12]
  https://www.personal.psu.edu/dsd11/EDS/EDS21Manual.pdf

More screening questionnaires can be found in Torstveit et al. (table 2)[4].

Athletes identified at any level of risk in Step 1 should be directed to complete Step 2. Note that there may be false positives (falsely identified) athletes in Step 1 which will be further clarified in subsequent steps. Having false positives decreases the risk of missing an athlete requiring care (false negatives).

Step 2: REDs Severity/Risk Assessment and Stratification and Sports Participation Guidelines

Step 2 includes a more in-depth assessment (See REDs Severity/Risk Assessment Table) and subsequent stratification (see REDs Stratification and Sports Participation Guidelines Figure below) of athletes into a four-level traffic-light (green, yellow, orange, and red) severity/risk stratification. The criteria in each traffic-light section are separated into primary and secondary indicators according to the level of scientific evidence, validity, and usability, and where scientifically supported, thresholds identified for each indicator are given[3]. Menstrual cycle, sex and thyroid hormone status indicators cannot be accurately assessed in athletes who are taking thyroid and/or sex hormone altering medications (e.g., hormone-based contraceptives). Therefore, do not score menstrual cycle for these athletes.



† Serious medical indicators of REDs and/or EDs requiring immediate medical attention, potential hospitalization and removal from training and competition (please see table 3), include: ≤ 75% median BMI for age and sex; Electrolyte disturbances; ECG abnormalities [(e.g., prolonged QTc interval or severe bradycardia (Adult: HR ≤ 30 bpm; Adolescent: HR ≤ 45 bpm)]; Severe hypotension: ≤90/45 mmHg; Orthostatic intolerance (Adult & Adolescent a supine to standing systolic BP drop > 20 mmHg and a diastolic drop > 10 mmHg); Failure of outpatient ED treatment program; Acute medical complications of malnutrition; Any condition that inhibits medical treatment and monitoring while training and/or competing.

Disclaimer: The IOC REDs CAT2 Severity/Risk Assessment and Stratification and Sport Participation Guidelines is not to be used in isolation and is not to be used solely for diagnosis. Furthermore, this tool is less reliable in situations where it is not possible to assess all indicators in theREDs Severity/Risk Assessment Table. The IOC REDs CAT2 Severity/Risk Assessment and Sport Participation Guidelines is not a substitute for professional clinical diagnosis, advice and/or treatment from a team of REDs health and performance experts led by a sports medicine physician. Along with the evaluation of health status presented here, sport participation decisions also need to be made in the context of various decision modifiers, such as level of the athlete, sport type, participation risk, conflict of interest, athlete/coach pressures, timing, and season etc.[13]. Abbreviations: BPM, Beats Per Minute; BMI, Body Mass Index; BP, Blood Pressure; ECG, Electrocardiogram; EDs, Eating Disorders; HR, Heart Rate; mmHg, millimeters Mercury; REDs, Relative Energy Deficiency in Sport.

Severe Primary Indicators (2 points)

- Primary amenorrhea (females: failure to reach menarche by age 15 when the development of secondary sexual characteristics is evident, or by age 14 years when no secondary sexual characteristics are present)
- Prolonged secondary amenorrhea (absence of 12 or more consecutive menstrual cycles) due to FHA
- Clinically low free or total testosterone (males: below the laboratory and age-specific reference range)

Primary Indicators (1 point)

- Secondary amenorrhea (females: absence of 3 to 11 consecutive menstrual cycles) caused by FHA
- Sub-clinically low free or total testosterone (males: within the lowest quartile of the laboratory and age-specific reference range)
- Sub-clinically or clinically low total or free T3 (within or below the lowest quartile of the laboratory and age-specific reference range)
- History of ≥1 high-risk (femoral neck or total hip, sacrum, pelvis) or ≥2 low-risk BSI (all other BSI locations) within the previous 2 years or absence of ≥6 months from training due to BSI in the previous 2 years
- Adults/Adolescents (age ≥15 years): BMD Z-score* <-1 at the lumbar spine, total hip, or femoral neck or decrease in BMD Z-score from prior testing (can occur from bone loss or inadequate bone accrual), using paediatric norms/software for age <20 years
- Child/Adolescent (age <15 years): BMD Z-score* <-1 at the spine or TBLH or decrease in BMD Z-score from prior testing (can occur from bone loss or inadequate bone accrual)
- A deviation of a paediatric or adolescent athlete's previous growth trajectory (height and/or weight)
- An elevated score for the EDE-Q global (>2.30 in females; >1.68 in males) and/or clinically diagnosed DSM-5-TR-defined ED (only 1 primary indicator for either or both outcomes)

*BMD assessed via DXA within ≤6 months. [In some situations, using a Z-score from another skeletal site (e.g., distal 1/3 radius when other sites cannot be measured or including total hip or femoral neck) in some older (>15 years) adolescents may be warranted].

Secondary Indicators

- Oligomenorrhea caused by FHA (>35 days between periods for a maximum of 8 periods/year)
- History of 1 low-risk BSI (see high vs low-risk definition above) within the previous 2 years and absence of <6 months from training due to BSI in the previous 2 years
- Elevated total or LDL cholesterol (above reference range)
- Clinically diagnosed depression and/or anxiety (only 1 secondary indicator for either or both outcomes)

Potential Indicators**

- Sub-clinically or clinically low IGF-1 (within or below the lowest quartile of the reference range)
- Clinically low blood glucose (below the reference range)
- Clinically low blood insulin (below the reference range)
- Chronically poor or sudden decline in iron studies (e.g., ferritin, iron, transferrin) and/or haemoglobin
- Lack of ovulation (via urinary ovulation detection)
- Elevated resting or 24-hour urine cortisol (above the reference range or significant change for an individual)
- Urinary incontinence (females)
- GI or liver dysfunction / adverse GI symptoms at rest and during exercise
- Reduced or low RMR <30 kcal/kg FFM/d or RMR ratio <0.90
- Reduced or low libido/sex drive (especially in males) and decreased morning erections (males)
- Symptomatic orthostatic hypotension
- Sleep disturbances
- Psychological symptoms (increased stress, anxiety, mood changes, body dissatisfaction and/or body dysmorphia)
- Exercise dependence/addiction
- Low BMI (requires validation in athlete populations of varying ages, sex & ethnicities)
- Extreme bradycardia [(HR<40 in adult athletes; HR<50 in adolescent athletes (<18 years)]
- Low systolic or diastolic BP (<90/60mmHg)

**Potential indicators are purposefully vague in quantification, pending further research to quantify parameters and cut-offs more accurately. Therefore, they are not allocated points for calculation in the IOC REDS CAT2.

Abbrivation: BP, Blood Pressure; BMD, Bone Mineral Density; BMI, Body Mass Index; BSI, Bone Stress Injury; DXA, dual-energy X-ray absorptiometry; DSM-5-TR, Diagnostic and Statistical Manual of Mental Disorders, 5th edition, text revision; ED, Eating Disorder; EDE-Q, Eating Disorder Examination Questionnaire; FFM, Fat-Free Mass; FHA, Functional Hypothalamic Amenorrhea; GI, Gastrointestinal; HR: Heart Rate; IGF-1: Insulin-like Growth Factor 1; kcal, kilocalories; LDL: Low-density lipoprotein; RMR, Resting Metabolic Rate; TBLH, Total Body Less Head; T, Testosterone; T3, Triiodothyronine; RMR, Resting Metabolic Rate; TBLH, Total Body Less Head; T, Testosterone; T3, Triiodothyronine

IOC REDs CAT2 Calculator Tool

In order to assist with the scoring of the IOC REDs CAT2, please find below an Online Calculator Tool.

Step 3: REDs Clinical Diagnosis and Treatment

The collective results from Step 1 and Step 2, informed by the Severity/Risk Stratification with the 4-colour traffic light Sports Participation Guideline, are not to be used in isolation - as a sports medicine physician (if a sports medicine physician is not available, a family physician / general practitioner doctor would be ideal) led final diagnosis is required.

Athletes categorised in the red, orange, or yellow light zones should receive medical evaluation and treatment. An accurate diagnosis and evidence-informed approach to REDs management are vital to avoid further harmful consequences of problematic LEA. The treatment of REDs should be undertaken by a team of health professionals including a sports medicine (if a sports medicine physician unavailable, a well-versedfamily physician / general practitioner is preferred) physician, sports dietician, exercise physiologist, athletic therapist or trainer, sports psychologist/ sports psychiatrist as needed. It is important to ensure the athlete's coach, and parents/guardians are aware of the diagnosis, as appropriate, and are supportive of the treatment plan, which may impact training. ***Patient confidentiality must be maintained.

Along with the evaluation of health status presented here, severity/risk stratification and sport participation decisions also need to be made in the context of various decision modifiers, such as

- competitive level of the athlete
- sport
- health risk of continued participation (based on indicators of greater severity)
- conflict of interest among those involved in this decision
- intrinsic and extrinsic athlete pressures related to timing in the competition season
- desire to compete
- sponsorship
- athlete's importance to the team

The cornerstone of treatment for all REDs-affected athletes is to restore the athlete to optimal energy availability by increasing energy intake and/or decreasing energy expenditure (training)[14-16]. This will require agreement amongst the athlete health and performance treatment team members and consistent messaging and support for the athlete as they navigate changes to their diet and/or training regimen. Athletes with REDs should be re-assessed regularly by the treatment team (every days to months, depending on severity), with key diagnostic indicators being re-tested as appropriate to help confirm restoration of normal body system function and well-being.

IOC CAT 2 Calculation Tool[4]

IOC REDs CAT2 Severity/Risk Stratification Calculator

Calculator based on: Stellingwerff, T., M. Mountjoy, W. T. McCluskey, K. E. Ackerman, E. Verhagen and I. A. Heikura (2023). "Review of the scientific rationale, development and validation of the International Olympic Committee Relative Energy Deficiency in Sport Clinical Assessment Tool: V.2 (IOC REDs CAT2)-by a subgroup of the IOC consensus on REDs." Br J Sports Med 57(17): 1109-1118.

https://bjsm.bmj.com/content/57/17/1109

Biological Sex: Female

Step 1: Enter the patient / athletes biological sex

REDS Severity / Risk Status: **Green**

Severe primary indicators (scores as double points)	Primary amenorrhea (Females: primary amenorrhea is indicated when there has been a failure to menstruate by age 15 in the presence of normal secondary sexual development (two SD above the mean of 13 years), or within 5 years after breast development if that occurs before age 10; or prolonged secondary amenorrhea (absence of 12 or more consecutive menstrual cycles) due to FHA	
Primary indicators (scores as single point)	Secondary amenorrhea (Females: absence of 3–11 consecutive menstrual cycles) caused by FHA	
	Subclinically or clinically low total or free T3 (within or below the lowest 25% (quartile) of the reference range)	
	History of ≥1 high-risk (femoral neck, sacrum, pelvis) or ≥2 low-risk BSI (all other BSI locations) within the previous 2 years or absence of ≥6 months from training due to BSI in the previous 2 years	
	Pre-menopausal females and males <50 years old: BMD Z-score* <-1 at the lumbar spine, total hip, or femoral neck or decrease in BMD Z-score from prior testing Children/adolescents: BMD Z-score* <–1 at the lumbar spine or TBLH or decrease in BMD Z-score from prior testing (can occur from bone loss or inadequate bone accrual).	
	A negative deviation of a paediatric or adolescent athlete's previous growth trajectory (height and/or weight)	
	An elevated score for the EDE-Q global (>2.30 in females; >1.68 in males) and/or clinically diagnosed DSM-5- TR- defined Eating Disorder (only 1 primary indicator for either or both outcomes)	
Secondary indicators	Oligomenorrhea caused by FHA (>35 days between periods for a maximum of 8 periods/year)	
	History of 1 low-risk BSI (see high vs low-risk definition above) within the previous 2 years and absence of <6 months from training due to BSI in the previous 2 years	
	Elevated total or LDL cholesterol (above reference range)	
	Clinically diagnosed depression and/or anxiety (only 1 secondary indicator for either or both outcomes)	

Step 2: Click on each blue box, and select **Yes or No** from the dropdown menu (which appears at the right side of the box) for each indicator in this column. Where you do not have information, leave blank.