

RELATIVE ENERGY DEFICIENCY IN SPORT (RED-S)



UNDERSTANDING
THE EFFECTS
OF LOW ENERGY
AVAILABILITY

TrueSport[®]

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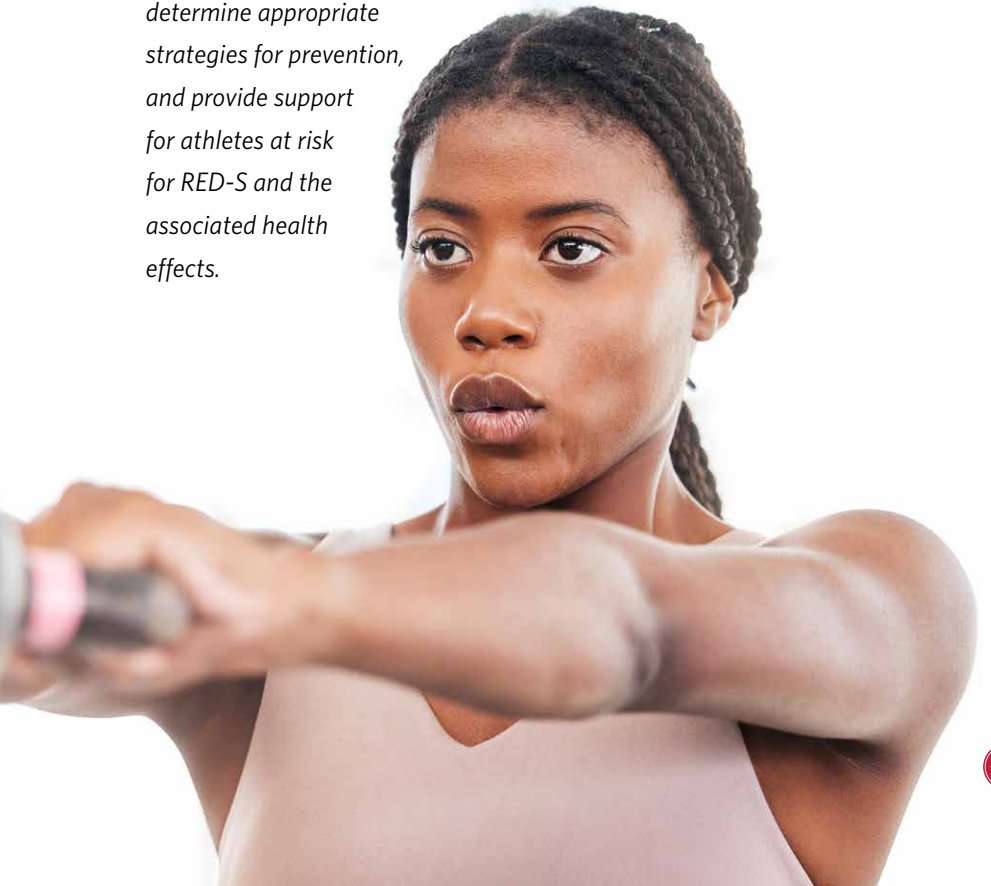


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INTRODUCTION AND PURPOSE

Given the multiple demands on the time and energy of young athletes – from academics, to sport, to social activities – it is not surprising that many are having difficulty making nutrition and training choices that support optimal health and performance. Unfortunately, those challenges can lead to serious medical concerns, including the development of “Relative Energy Deficiency in Sport” (RED-S) syndrome, which is common in athletic populations. RED-S describes changes that occur in health and body function when athletes do not have enough energy available to support optimal health AND optimal sports performance. This guide will provide practical information to help caregivers, athletes, and coaches identify possible risk factors for RED-S, determine appropriate strategies for prevention, and provide support for athletes at risk for RED-S and the associated health effects.



What Is Relative Energy Deficiency In Sport (RED-S)?

What is RED-S?

Relative Energy Deficiency in Sport, or RED-S, describes changes that occur in health and body function when athletes do not have enough energy available to support optimal health AND optimal sports performance.

What changes occur with RED-S?

When athletes do not take in enough calories to fully support sport-related activity and daily function, certain functions in the body slow down to help conserve energy. Although this is an area of relatively new and ongoing research, current data indicates changes related to RED-S occur in the following systems:

- **Endocrine:** The endocrine system is the dominant influence on metabolic rate, growth, and pubertal development. Changes in the endocrine system that occur with RED-S have far-reaching effects throughout the body, including reduced metabolism in both females and males, reduced testosterone levels in males, and reduced estrogen levels in females. RED-S also produces changes in menstrual cycles in females.
- **Bone health:** The combination of endocrine dysfunction and low-calorie intake leads to bone loss and a reduction in bone density, which increases risk for osteoporosis and stress fractures.
- **Immune:** Athletes with RED-S have higher rates of illness and appear to have lower levels of antibody production and secretion, which protect athletes from infection.
- **Gastrointestinal:** RED-S produces a general slowing of intestinal function, possibly leading to constipation.
- **Cardiovascular:** Endocrine changes seen with RED-S may contribute to early atherosclerosis (i.e., “hardening of the arteries”) and endothelial dysfunction, which leads to difficulties with dilation of the arteries that helps to regulate blood flow in the heart and throughout the body.
- **Hematology:** Impaired protein synthesis, coupled with increased risk of iron deficiency, can lead to a reduction in red blood cell production and the development of anemia.



What Causes RED-S?

The primary cause of RED-S is low energy availability (LEA).

LEA is central to the development of RED-S and is defined as an energy deficiency relative to the balance between energy intake (i.e., calories) and energy expenditure required for activities of daily living, health, growth, and sport activities (i.e., training and competition). Although traditionally associated with disordered eating or excessive rates of weight loss, it is now recognized that RED-S can be present even when energy intake and total energy expenditure are balanced, and the athlete is weight stable.

In athletes, daily calorie intake needs to cover the energy requirements of training and competition, as well as the energy needed to support growth, development, and daily metabolism. Calories consumed in food and beverages are used by the body in many different ways, and the body needs to “make do” with the calories athletes eat and drink every day.



LEA occurs when calorie intake is insufficient to support all of the following:

GROWTH AND DEVELOPMENT



Throughout childhood and adolescence, calories are needed to build bone, muscles, and other tissues. Calorie needs are higher during periods of growth, particularly during the peak growth spurt in adolescence.

BODY MAINTENANCE



Calories are needed to support the body's resting metabolism, which includes the many different processes needed for daily function. This includes things like breathing, circulating blood, controlling body temperature, digestion, and function of the brain and nervous system.

PHYSICAL ACTIVITY AND ATHLETIC PERFORMANCE



Calories are used to generate the energy needed for body movement. Lower intensity activities, such as “day-to-day” tasks at school and home primarily use calories from fat, and higher intensity activity associated with most sport training and performance uses more calories from carbohydrates.

TRAINING, RECOVERY, AND TISSUE REPAIR



Calories are needed to repair the breakdown that occurs in bone, muscle, and other tissues and to build backup fuel stores to prepare for the next workout.

SYMPTOMS AND DIAGNOSIS

How is LEA Diagnosed?

Precise determination of LEA depends upon accurate assessments of:

- Body composition
- Calorie intake
- Resting metabolic rate (i.e., the energy required for basic living functions)
- Calorie expenditure during exercise/training

In most community settings, these measurements are difficult to obtain, and the diagnosis of RED-S and LEA depends upon recognition of the “overall picture” in athletes who present with any, or a combination of, the following symptoms.

SYMPTOMS OF LEA*

1. *Reduced training capacity*
 - a. *Delayed or prolonged recovery times*
 - b. *Excessive fatigue*
 - c. *Concentration difficulties*
2. *Reduced athletic performance*
3. *Repeated episodes of, or prolonged recovery from, injury or illness*
4. *Change in mood (i.e., increased anxiety or depression)*
 - a. *Preoccupation, or obsessive behavior, regarding diet and training*
5. *Failure to lose weight despite low calorie intake*
6. *Reduced or low bone density*
 - a. *Stress fractures (especially if recurrent or slow to heal)*
7. *Cessation or changes in menstrual cycle*
 - a. *Less than nine menstrual cycles/year is an indicator of LEA*
8. *Low blood count, iron levels, and/or vitamin D*

* Adapted from USOPC: <https://www.teamusa.org/-/media/TeamUSA/Nutrition/LEA-Fact-Sheet.pdf?la=en&hash=4CB27CCC4C1309A5F7BC7ED79EAC7EF83D5A3519>



RISK FACTORS

Why Do Some Athletes Develop LEA?

Studies have found that the prevalence of LEA in athletes ranges from 14-63 percent, depending upon the specific population studied. Initial studies in this area were primarily focused on female athletes. Although females are still considered to be at higher risk for LEA, there is growing recognition that LEA occurs in male athletes as well.

The following factors appear to increase the risk for LEA development. Please note that some athletes may belong to two or more of these risk groups.

- Inadvertent low caloric intake due to:
 - Scheduling challenges (i.e., “too busy to eat”)
 - Food insecurity/availability
 - Lack of knowledge regarding appropriate calorie intake for athletes
 - Lifestyle changes (e.g., students moving to college and learning to nourish themselves)
- Diet restrictions:
 - Vegetarian/vegan diets
 - Religious dietary restrictions
 - Weight loss attempts
 - Food preferences (“picky eaters”)
 - Disordered eating
- Sport-specific factors (often related to participation in weight sensitive sports):
 - Endurance athletes (e.g., distance runners, cyclists, triathletes)
 - Weight-classified athletes (e.g., wrestling, lightweight rowing)
 - Aesthetic sports (e.g., gymnastics, figure skating, dance)
- Psychological factors:
 - Perfectionism
 - Body dysmorphia
 - Eating disorders/disordered eating

PHYSICAL EFFECTS

What Are The Short-Term And Long-Term Effects of LEA?

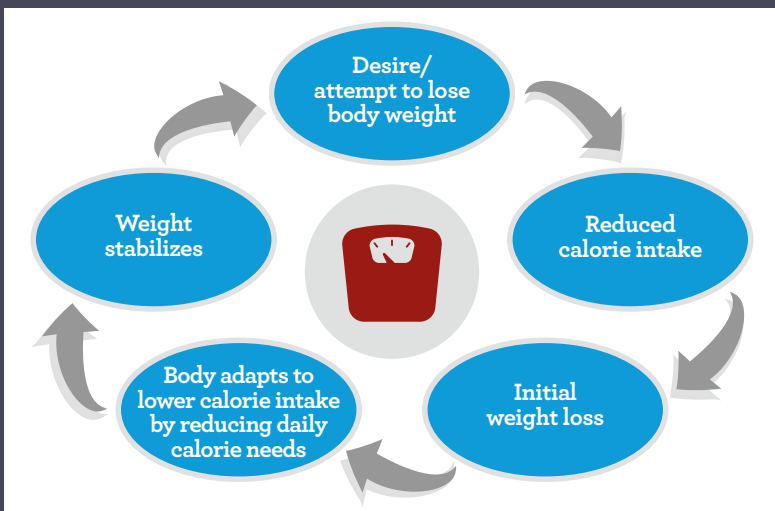
Short-term periods of LEA may result in initial weight loss. Weight is lost as the body breaks down fat and muscle to provide energy for activity as well as daily maintenance and function. In weight-sensitive sports, this initial weight loss may produce short-term improvements in performance.

With longer periods of LEA, the body learns to “make do” with this lower calorie intake and adapts to this low level by:

- Reducing the resting metabolic rate (in females this can happen after just four days of LEA).
- Reducing the energy used to refuel and recover from intense training.

If activity levels remain the same, this creates a new “steady state” where the body now needs fewer calories per day, and weight loss ceases.

At this point, athletes who desire to lose additional weight will need to lower their energy availability further through additional reductions in calorie intake and/or increases in exercise. This produces an even lower metabolic rate, and ultimately the weight plateaus at this lower level of calorie intake. This creates the cycle shown below:



This cycle repeats itself as the body tries to conserve energy when energy availability is reduced, ultimately creating the health and performance changes associated with RED-S. In these cases, body weight is maintained at calorie levels that are insufficient to support healthy function, and a number of body functions that are “less essential” for survival slow down. Reproductive function and bone health are the two systems that have been best studied in this field, and there is concern that these cycles of metabolic downregulation are often seen during the development of eating disorders in athletes.

Although calorie intake does affect weight, due to the patterns described above, it is important to emphasize that:

1

Low or inadequate calorie intake does not always produce weight loss.

2

Weight cannot be used as a single indicator of adequate calorie intake.

3

Appropriate restoration of calorie intake does not always result in weight gain.





How Does Weight And Energy Availability Impact Sport Performance?

For every athlete, there are a range of weights associated with optimal health and long-term athletic performance. In some sports there are widely held perceptions that athletes perform better at lower weights. It is important to acknowledge that for some “weight sensitive sports” (e.g., distance running, gymnastics, dance, weight-classified sports), short-term performance may be enhanced when competing at a lighter weight. However, bodyweights that are maintained in a state of LEA result in reductions in performance and increased injury risk over time.

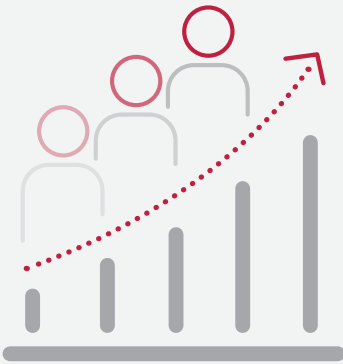
Although LEA and RED-S impact athletic performance on multiple levels, this is a fairly new field of research and data is continuing to emerge. Here’s what we know now:

- **Muscle growth and development:**
 - Maintenance of muscle tissue, improvements in strength, and recovery from injury depend upon the body’s ability to incorporate protein into muscles tissue. One study in adults found that rebuilding muscle at rest was reduced by 27 percent within five days of onset of LEA (30 kcal/kg or less).
- **Growth/general tissue maintenance and repair:**
 - Within several days of onset of LEA, secretion of insulin-like growth factor (one of the most important hormones in the body for growth and tissue repair) is reduced by 20-30 percent.



- **Fuel for exercise:**
 - Young athletes have less fuel (glycogen) stored in their liver and muscles than mature athletes and are more reliant upon blood glucose for energy during exercise. The vast majority of studies find significant reductions in blood glucose with LEA.
- **Time lost due to illness:**
 - Athletes who screened at risk for LEA appear to have training absences due to illness that are three times higher than athletes without risk for LEA.
- **Effects on bone health:**
 - LEA reduces the formation of new bone. This reduces the body's ability to repair microtrauma that occurs in bone during training, and significantly increases risk for stress fractures. This effect on bone is more pronounced in females than in males.
- **Testosterone:**
 - LEA reduces testosterone levels in males, which can negatively impact sleep, mood, bone mass, and lean muscle mass.

HOW DOES ENERGY AVAILABILITY IMPACT GROWTH?



Health care providers use growth charts developed by the U.S. Center for Disease Control to follow changes in height and weight in children and adolescents. As a general rule, growth tends to follow expected percentile lines throughout development and significant deviations away from this rate of expected growth will often prompt further evaluation by health care providers. It's also worth noting that in younger athletes, LEA may slow down normal weight gain rather than produce weight loss.

What Is The Female Athlete Triad?



The Female Athlete Triad is typically considered the combination of restrictive eating behaviors, changes in the menstrual cycle, and reduced healthy bone formation in females. The health-related impacts of LEA were initially studied as part of the Triad. Although the Triad was originally connected to athletes with eating disorders, there has been more recent recognition of the Triad as a spectrum of effects that occur in females as energy availability is decreased. It is now recognized that energy availability, rather than eating disorders per se, is the primary cause for the changes seen in the Triad, and many experts now recognize the Female Athlete Triad as part of the spectrum of RED-S.

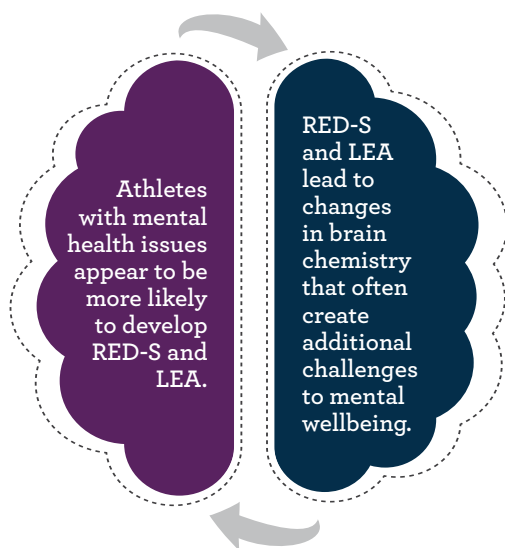
In addition, there has been more recent recognition that a similar pattern is seen in males with LEA, leading to reductions in testosterone levels and lowered bone density. Male athletes at the highest risk for these effects include those in weight classified sports (wrestling and other combat sports), as well as runners, cyclists, rowers, and jockeys. Some authors refer to this as the Male Athlete Triad. This is a fairly recent area of study, although it appears that males are not as vulnerable to these changes as females and require longer periods of more severe calorie restriction.



MENTAL HEALTH EFFECTS

What Are the Mental Health Effects Associated With RED-S and LEA?

The relationships between mental health and RED-S/LEA are complex.



Pressure associated with performance and appearance may drive some athletes toward disordered eating behaviors and/or compulsive exercise, which can lead to RED-S. Athletes with perfectionism are at particular risk. Perfectionism is often seen in young athletes who feel the need to simultaneously excel in sports, school, and social environments, and is often magnified by social media. **Perfectionism is not just a drive toward excellence but a consistent and persistent intolerance of any flaw or perceived weakness, and it creates unrealistic self-expectations.**

Athletes with perfectionism are at a higher risk for eating disorders, compulsive exercise, burnout, anxiety/depression, and even suicide.

A common manifestation of perfectionism is *body dissatisfaction*, which includes persistent negative feelings about one's appearance and body shape. Athletes with body dissatisfaction usually believe that they are not "thin enough" or "muscular enough," and spend large amounts of time and energy specifically pursuing a leaner and more muscular appearance. Body image often worsens when athletes compare themselves to idealized images seen on social media.



In many cases, family and friends will try to convince athletes with body dissatisfaction and disordered eating that their self-perception is incorrect. However, it is important to recognize that these beliefs are usually illogical (and firmly entrenched), and care from a mental health expert is often required.



TREATMENT

How Can We Help Athletes With Suspected RED-S/LEA?

The approach to helping athletes with possible RED-S/LEA depends upon:

1. Underlying factors that predisposed the athlete to RED-S/LEA.
2. Health-related impacts (physical and mental).

For some athletes, LEA is unintentional and primarily due to a lack of knowledge regarding healthy sports training and nutrition. In these cases, educating and helping athletes develop healthy eating strategies enables them to make better choices.

These athletes might benefit from:

- Information from reliable sports nutrition sources, such as the *TrueSport Nutrition Guide*.
 - Some athletes may benefit from individualized guidance with a registered dietitian.
- Team-based efforts, such as:
 - Reviewing a daily nutrition tip, or viewing a quick video on the topic, at the beginning or end of practice.
 - Providing appropriate pre- or post-training snacks (either on-site or “to go”).
- For athletes with food insecurity, *Feeding America* can help families identify local sources for healthy food.

In other athletes, LEA is the result of intentional dietary restriction, or excessive training, in an effort to lose weight or enhance muscularity. For many of these athletes, LEA reflects underlying issues related to body image, self-esteem, and/or disordered eating, which will also need to be addressed during treatment. Although education and support from coaches, teammates, and family are important, treatment strategies for RED-S should be developed by a registered dietitian, sports medicine physician, and/or other health care professional who can help guide athletes through the process of restoring healthy energy availability and full physiologic function, as well as determine safe levels of continued participation in sport during this process.

What Should Athletes Expect During RED-S/LEA Treatment?

The goal for RED-S treatment is NOT as simple as just advising athletes to eat more. Sudden increases in calorie intake when the body has a down-regulated metabolism can have significant and unpleasant effects on the athlete including:

- Nausea/vomiting/upset stomach
- Constipation/diarrhea
- Bloating

Appropriate dietary strategies developed by licensed professionals generally focus on:

- Slowly increasing daily calorie intake with small, frequent meals.
- Assuring adequate carbohydrate intake, with low levels of fiber.
- Addressing nutrient deficiencies (including iron, calcium and vitamin D).

Athletes with RED-S may be in a relative state of dehydration and when normal carbohydrate and fluid intake are restored, they may note a several pound gain in water weight and feel bloated. Although this feeling is temporary, it may be very discouraging to the athlete, and they may benefit from added support during this time.

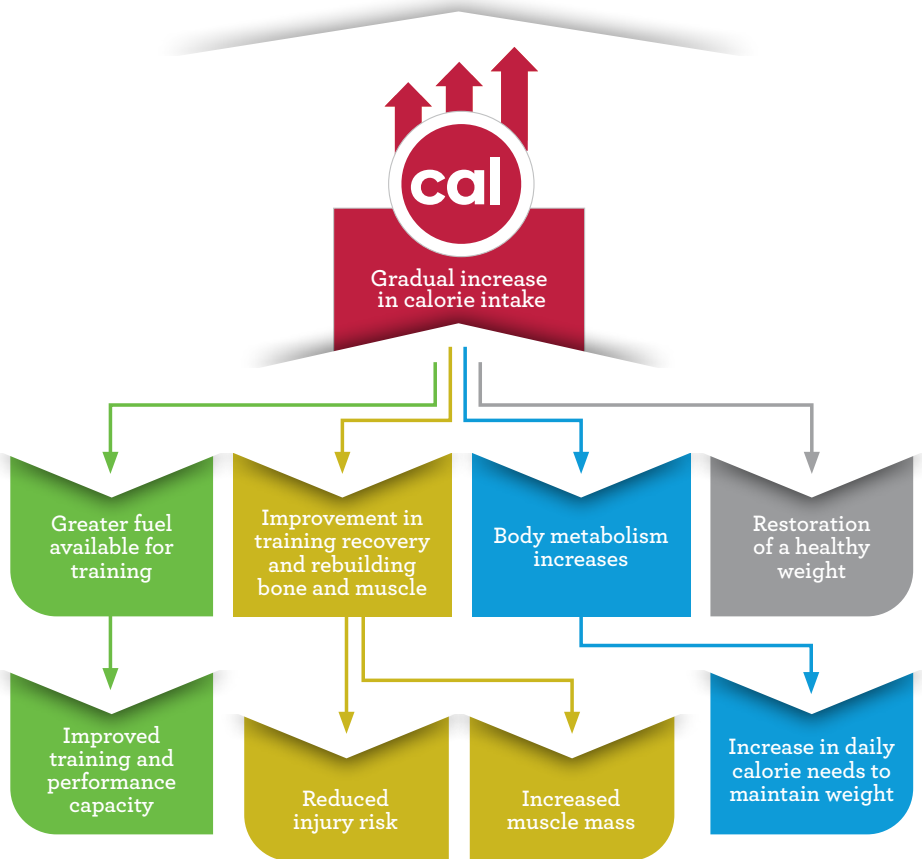
It's important for athletes and parents to be aware that increasing energy availability will often result in restoration or commencement of healthy menstrual function. For some athletes, this will be a significant change in their life that they may not be expecting.

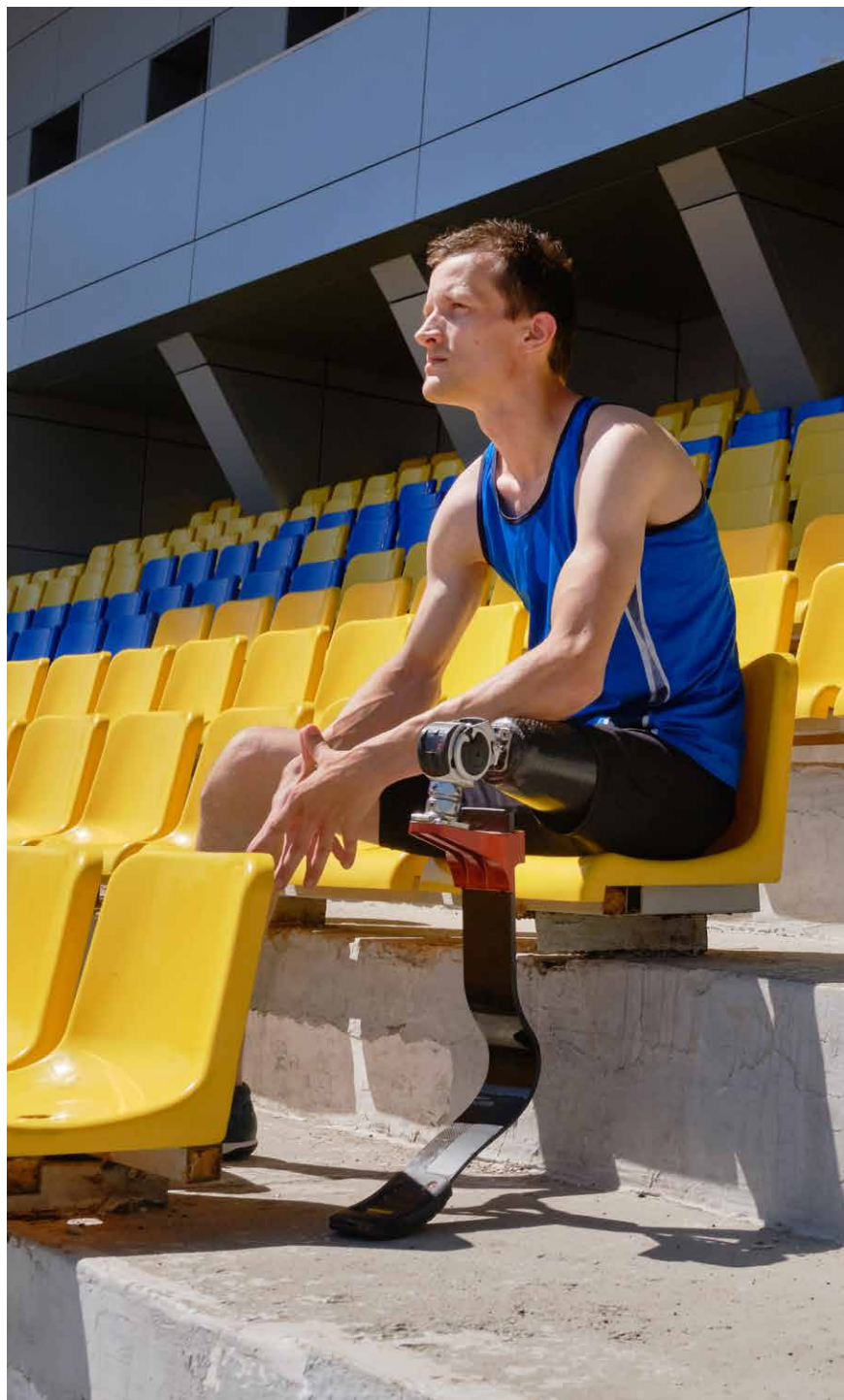


For athletes who are underweight, or experiencing poor growth, correction of LEA and RED-S usually results in restoration of healthy weight and growth. However, it is important to remember for athletes with LEA that:

- Reducing calorie intake does not always produce weight loss.
- Increasing calorie intake does not necessarily create weight gain.

Athletes at (or above) a healthy weight often fear that correction of LEA will automatically produce significant weight gain. They should be reassured that this is NOT necessarily the case. The goal in athletes who are at a healthy weight, or overweight, is to gradually restore adequate amounts of available energy, so that the body has an opportunity to “up-regulate” metabolism with the added calories used to restore function, rather than increase fat mass. This process is shown below.





GUIDANCE FOR COACHES



For many athletes, coaches exert significant influence over their training and dietary choices, and even casual comments regarding an athlete's weight or body size can have profound and lasting effects on the athlete. As such, coaches shouldn't comment on weight, appearance, and food-related behaviors.

Here's how coaches can help prevent and address LEA and RED-S.

1. Role model healthy eating and training.
2. Establish a team culture of healthy behaviors, care, compassion, and shared goals.
3. Shift emphasis away from short-term performance goals and toward longer-term development of athletic skill, performance, and athlete health.
4. Focus on high quality training AND high-quality recovery.
 - a. Although bouts of high training volume and intensity can be an important part of a periodic training program, athletes respond best when training volume and intensity are variable, with at least 36-48 hours between high intensity sessions.
 - b. During times of high training demands, athletes should be directed to:
 - Increase energy/calorie intake accordingly.
 - Focus on appropriate recovery, including adequate sleep, physical rest, and overall stress reduction.
5. Do not promote weight loss. Direction around weight-related goals should come from a registered dietitian or other health care professional and not from coaching staff.
6. If you suspect LEA or RED-S in an athlete, the appropriate caregivers and/or medical staff should be informed. Any conversation about RED-S and LEA should focus on overall athlete wellbeing rather than weight and food.
 - These conversations should be handled in a discreet way that's comfortable for the athlete. If the conversation is with an athlete who is a minor, another responsible adult should be present, and the interaction should always be observable and interruptible.
 - Share your observations and reason for concern (e.g., "I have noticed that..." or "I wanted to check in with you about...").
 - Don't be surprised by denial and defensiveness.



GUIDANCE FOR CAREGIVERS



Addressing concerns with a child in your care is never easy and your words and behaviors can have a significant impact.

Here are some ways to help if you're concerned about LEA and RED-S.

1. Role model healthy eating and training behaviors.
2. Seek opportunities to learn about LEA and RED-S, both on your own and with your child.
3. Open the lines of communication, with the following in mind:
 - a. Timing and location are important.
 - b. Give the athlete a "heads up" that you have something you would like to discuss.
 - c. Choose a time and location that is comfortable and free of distraction.
 - d. Discussing personal struggles with eating, diet, and training can help open lines of communication on these topics.
 - e. Use "I" statements to express your concerns and observations and ask open-ended questions to encourage further discussion (i.e., "I've noticed that you don't seem to have as much energy lately. How are things going for you at school and with soccer?").
 - f. Be prepared to listen.
 - g. Initial conversation attempts may be met with resistance or denial, but let the athlete know you are there to provide support and to help locate resources for them.
4. Enlist health care professionals to help address LEA and RED-S concerns.
 - a. Preparticipation evaluations and "well-child checks" provide good opportunities for conversation between providers and the athlete.
 - Inform the provider ahead of time of your concern.
 - b. Offer to set up an appointment with a registered sport dietitian to discuss nutrition strategies for optimal performance.



GUIDANCE FOR ATHLETES



It is important to remember that teammates cannot “fix” each other, but they can help each other by listening, showing compassion, and providing support. Becoming knowledgeable about RED-S, LEA, and disordered eating is a good first step.

Here are other ways to help.

1. Team captains and senior members can be role models for healthy eating, training, and recovery, and can help establish a team culture of trust, support, and healthy behavior.
2. Raising possible concerns about physical and mental health can be sensitive and difficult, and making a successful connection depends upon the following:
 - a. Right place
 - The setting should be comfortable for all participants.
 - Discussions during a walk or light training may be more comfortable and open than sitting in a quiet space.
 - b. Right time
 - Avoid times of high stress or distraction.
 - Ask permission to have a discussion (e.g., “Can we talk soon? Is now good?”).
 - c. Right person
 - Someone with a close, established relationship with the athlete who is prepared to listen and willing to provide ongoing support.
 - d. Use “I” statements to share observations and reason for concern (e.g., “I’ve noticed that…”).
 - e. Focus on feelings and emotions rather than food and weight.
 - f. Do not be discouraged or surprised by initial denial and defensiveness (e.g., “I’m fine.” “Nothing’s wrong.”).
3. Seek advice from trusted adult professionals who can provide guidance on how to help the athlete get further assistance, such as a:
 - a. Team athletic trainer
 - b. Team physician
 - c. School nurse or guidance counselor



Acknowledgement:

A very special thanks to Dr. Michele LaBotz for contributing the content for this publication.

Michele LaBotz, MD, FAAP, CAQSM is a sports medicine physician with experience caring for athletes at all levels of sport. She is particularly interested in the principles of nutrition and supplement use, injury prevention, physical literacy, and mental health in young athletes. LaBotz writes and speaks nationally on these topics and was the co-author of the American Academy of Pediatrics' (AAP) clinical report on the use of performance-enhancing substances in young athletes. She previously served as policy coordinator for the AAP's Executive Council on Sports Medicine and Fitness and now serves on the board of directors for the Maine Chapter of the AAP and the Taylor Hooton Foundation.

After completing premedical training at the University of Michigan and University of California, Irvine, LaBotz graduated from Dartmouth Medical School. She trained in pediatrics at University of Wisconsin at Madison and Maine Medical Center, as well as in sports medicine at the University of North Carolina at Chapel Hill. LaBotz subsequently served as a team physician and helped establish the sports medicine fellowship at the University of Hawai'i. She and her family then returned to Maine, where she began a private practice career at InterMed's sports medicine clinic in South Portland.

LaBotz is one of the co-creators of *Physical Literacy for All Youth* in Maine (PLAY ME) which promotes physical literacy assessment and development in community and medical settings.

LaBotz resides on Cousins Island in Yarmouth, Maine. Her husband recently retired from the golf profession and their daughter is a former competitive gymnast.



Resources:

IOC Consensus Statements

The IOC consensus statement: beyond the Female Athlete Triad —Relative Energy Deficiency in Sport (RED-S)

<https://pubmed.ncbi.nlm.nih.gov/24620037/>

IOC consensus statement on Relative Energy Deficiency in Sport (RED-S): 2018 update

<https://bjsm.bmj.com/content/52/11/687>

TrueSport

Nutrition Guide

<https://truesport.org/wp-content/uploads/TSNutritionGuide.pdf>

Other nutrition resources

<https://truesport.org/teach-learn/truesport-topics/nutrition/>

US Olympic and Paralympic Committee

Team USA: Low Energy Availability

<https://www.teamusa.org/-/media/TeamUSA/Nutrition/LEA-Fact-Sheet.pdf>

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