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Relative Energy Deficiency in Sport (RED-S): Evaluating the Impact on Health and Performance

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Relative Energy Deficiency in Sport (RED-S)

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Event Materials

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Continuing Education

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Today's Presenter

Susan Kundrat, MS, RDN, LDN

Clinical Professor, Department of Kinesiology
University of Wisconsin-Milwaukee

- Registered Dietitian Nutritionist with over 30 years of experience working with athletes and active people to enhance their health, well-being, and sports performance
- Former Sports Dietitian at the University of Illinois in Urbana-Champaign and consulting Sports Dietitian at Northwestern University, Bradley University, the University of Evansville, and the University of Wisconsin-Milwaukee
- Teaches courses in basic nutrition, sports nutrition, career opportunities and leadership in the nutrition field, nutrition communication and education, and food/nutrition security

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Learning Objectives

1. Define relative energy deficiency in sport (RED-S).
2. Describe the key factors in assessing RED-S in athletes and active people.
3. Explain how RED-S impacts health and sports performance in athletes and active people.
4. Calculate energy availability.

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What is RED-S?

- **Relative Energy Deficiency in Sport**
- "The syndrome of RED-S refers to ***impaired physiological function*** including, but not limited to, metabolic rate, menstrual function, bone health, immunity, protein synthesis, and cardiovascular health caused by ***relative energy deficiency***."

Mountjoy et al. 2018, IOC consensus statement on relative energy deficiency in sport – 2018 update. International Journal of Sport Nutrition and Exercise Metabolism, 28, 1-19.

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What is RED-S?

- Original publication *"Beyond the Female Athlete Triad: Relative Energy Deficiency in Sport (RED-S)"* published by the International Olympic Committee (IOC)

Mountjoy et al. 2014, The IOC consensus statement: beyond the female athlete triad – relative energy deficiency in sport (red-s). British Journal of Sports Medicine, 48)7), 491-497.

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The Female Triad - History

- 1980s – Professor Barbara Drinkwater, a pioneer in research on the health and well-being of female athletes and women's health and champion for women's equality in sport, brought attention to the relationship between amenorrhea, bone health, and dietary intake/energy availability – then known as the Female Athlete Triad.
- This early work focused on the how menstrual status impacted bone health and the positive effects on bone health with resumption of menses.
- This groundbreaking work set the foundation for RED-S.

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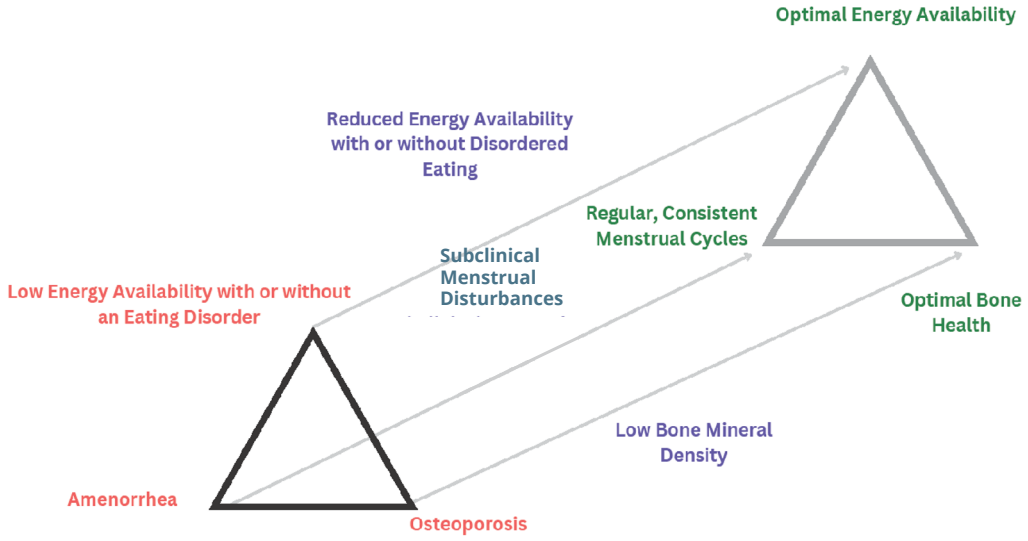
The Female Athlete Triad



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RED-S Includes Male Athletes

- "Although much of the research in the field has been devoted to the female athlete, there is sufficient published evidence to support the premise that male athletes are also affected by relative energy deficiency."
- Males at particular risk are those in sports with high training volume or demand leanness / have weight categories.

Mountjoy, "Relative Energy Deficiency in Sport", ASPETAR Sports Medicine Journal, October 2015

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What is RED-S?

- **Relative Energy Deficiency in Sport**
- "The cause of this syndrome is ***energy deficiency relative to the balance*** between dietary energy intake and energy expenditure required for health and activities of daily living, growth and sporting activities."

Mountjoy et al. 2018, IOC consensus statement on relative energy deficiency in sport – 2018 update. International Journal of Sport Nutrition and Exercise Metabolism, 28, 1-19.

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RED-S Key Definitions

- ***Energy balance:*** the amount of dietary energy added to or lost from the body's energy stores after all the body's physiological systems have completed their work for the day
- ***Energy balance*** = energy intake-total energy expenditure

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RED-S Key Definitions

- ***Energy deficit:*** the discrepancy in energy balance when dietary energy intake is less than total energy expenditure, such that energy is lost from the body's energy stores and/or compensatory mechanisms take place to reduce total energy expenditure.

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Respond using the poll pop-up feature.

Poll

Have you heard of the term "energy availability?"
If so, do you use it with athletes?

A. I have not heard of the term "energy availability."
B. I am familiar with the term "energy availability" but do not know what it means.
C. I know of the term "energy availability" and understand its meaning.
D. I understanding the term "energy availability" and use it in my practice with athletes.

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RED-S Key Definitions

- ***Energy availability:*** the amount of dietary energy remaining to support metabolic systems in the body after the energy cost for a particular system has been removed. In the case of athletes, energy availability is the amount of energy remaining to support all other body functions after the energy expended in exercise and sporting activities is removed from energy intake.
- ***Energy availability*** = energy intake – energy expended in exercise

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RED-S Key Definitions

- ***Low energy availability:*** occurs when 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

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RED-S Key Definitions

- ***Relative energy deficiency*** reflects that low energy availability can occur ***even in the scenario where energy intake and total energy expenditure are balanced*** (there is no overall energy deficit).

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Athletes at a Higher Risk for RED-S

- Athletes in sports judged for aesthetics
- Athletes in endurance-based sports or long-distance sports
- Athletes in weight category sports
- Athletes in weight-dependent sports
- Military personnel with high energy demands

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However, …

- All athletes and active people can be at risk for RED-S.
- Understand and assess ALL athletes with their individual needs, experiences, challenges, and goals.

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Practical Tips from an Expert

"The biggest thing to understand is that energy deficit is not a female vs. male issue, a body type, or a sport-specific issue.

There are both acute and chronic risks and outcomes related to short-term (as short as a day) and long-term energy deficits."

Randy Ballard, MS, ATC
Associate Director of Athletics, Sports Medicine / Director of Integrated Performance University of Illinois

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Potential Experiences Leading to Low Energy Availability

- Lack of adequate food / food insecurity – which may be particularly common in collegiate athletes
- Misconceptions about how much food / how many calories are required on a daily basis
- Poor appetite due to medications, other health issues
- Restricting energy intake in an attempt to lower weight and/or enhance performance
- Long training hours, classes, and other commitments limit opportunities to eat

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Energy Deficiency in Service Members

- **The physical and psychological challenges faced by military personnel are inherently different than those faced by athletes.**
- The implications of impaired performance are also different between military and sporting populations; military tasks require a unique combination of physical and cognitive effort in unpredictable and stressful environments, and the consequences of underperformance can be catastrophic.
- Training for sport is focused on optimizing performance and often a desire for "leanness," whereas military training prepares individuals for the hostile physical and psychological conditions of combat (e.g., concomitant periods of prolonged exercise, food restriction, sleep deprivation, extreme environments, and psychological stress).
- Military tasks are diverse (e.g., combat field exercises, casualty extraction, weapon handling, repetitive lifting, prolonged load carriage) and impose a wide range of physiological stresses. Aerobic capacity and muscle strength, power, and endurance are all important for performing military tasks.

O'Leary TJ, Wardle SL and Greeves JP (2020) Energy Deficiency in Soldiers: The Risk of the Athlete Triad and Relative Energy Deficiency in Sport Syndromes in the Military. Front. Nutr. 7:142. doi: 10.3389/fnut.2020.00142.

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Energy Deficiency in Service Members

- Studies that have monitored both energy expenditures and energy intake in military personnel have found energy deficits.
- In addition to high energy expenditures, restricted energy intake is a common factor.
- Restricted energy intake can be a result of logistical barriers to eating or as a training objective, a hesitancy to carry extra weight, sub-optimal dietary practices, or suppressed appetite or menu fatigue.

O'Leary TJ, Wardle SL and Greeves JP (2020) Energy Deficiency in Soldiers: The Risk of the Athlete Triad and Relative Energy Deficiency in Sport Syndromes in the Military. Front. Nutr. 7:142. doi: 10.3389/fnut.2020.00142.

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Threshold of Energy Deficit and Lower-Body Performance Declines in Military Personnel

- Out of 632 initial studies reviewed, **nine studies** were assessed for energy deficits and the relation to lower body power and strength.
- The **combination of Energy Balance (EB) and duration** was associated with decreases in lower body power and strength.
- Calorie deficits of -5,686 to -19,109 over an operation (or <3% body weight losses) were associated with 0-2% decreases in lower-body power and strength.
- Calories deficits greater than -39,243 to -59,377 over an operation (or >8% body weight losses) were associated with significant (7-10%) declines in lower-body power and strength.

*Murphy, N.E., Carrigan, C.T., Philip Karl, J. et al. Threshold of Energy Deficit and Lower-Body Performance Declines in Military Personnel: A Meta-Regression. Sports Med **48**, 2169–2178 (2018). https://doi.org/10.1007/s40279-018-0945-x*

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How Does Dieting Play a Role?

- Restrictive diets
- Diets that promise fast weight loss
- Diets that cut out food groups or certain foods
- Diets that limit the time of day an athlete can eat

CLEAN EATING

INTERMITTENT FASTING

KETO

GRAIN-FREE

PALEO

VEGAN

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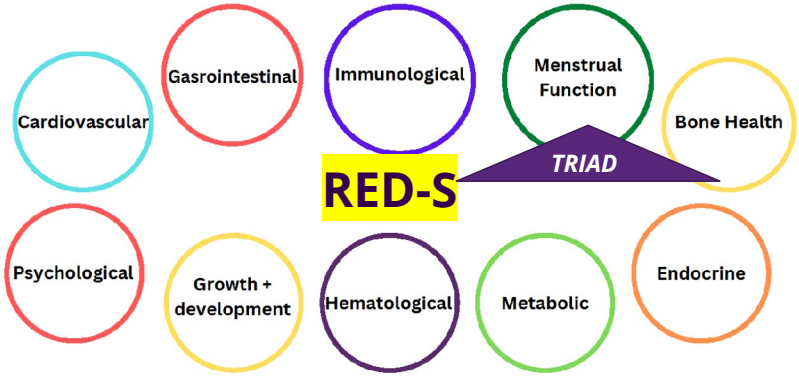
Health Consequences of Relative Energy Deficiency in Sport (RED-S)



Adapted from: Mountjoy et al. Br J Sports Med 2015;49:417-420

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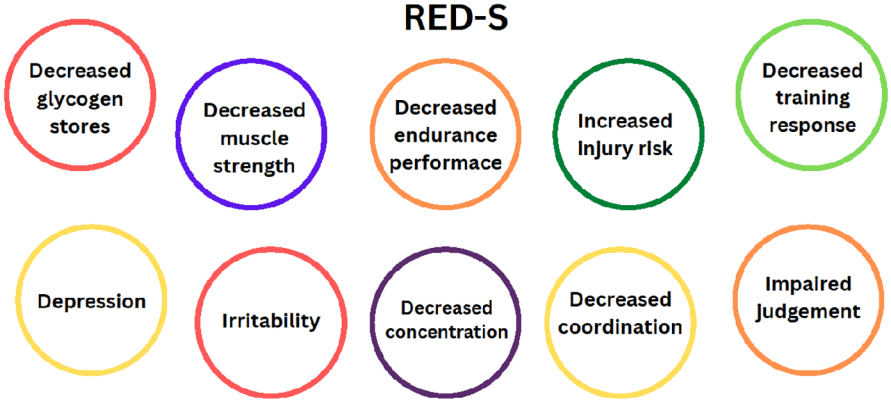
Potential Performance Effects of Relative Energy Deficiency in Sport

RED-S



Adapted from: Mountjoy et al. Br J Sports Med 2015;49:417-420

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What Concerns Do Sports Dietitians Most Commonly See with RED-S?

- Amenorrhea
- Bone Stress injuries
- Other sports-related injuries
- Recurrent Illnesses
- Interruption in competition
- Mood disturbances
- Extreme fatigue
- Gastrointestinal problems
- Underweight
- Under-fat
- Restrictive behaviors

Jennie Zabinsky, M.Ed., RD

Christina Weidman, MS, RDN, CSSD, LDN

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Questions

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Correlation between menstrual irregularity (MI) and musculoskeletal injury (INJ)

Freepik / CC0

- 249 female athletes from 3 high schools
- Competed in 33 interscholastic, school-sponsored sports teams, dance teams, cheerleading, or pompom squads during 2006-2007 school year.
- Prevalence of MI and INJ were 19.7% and 63.1%.
- Athletes who reported MI sustained a higher percentage of severe injuries.
- Athletes with MI were almost 3 times more likely to sustain an injury resulting in 7 or more days lost from sport than those with 7 or fewer days lost from sport.

Thein-Nissenbaum et al. 2012. JATA:47(1):74-82.

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Menstrual Irregularities in British Servicewomen

- Survey of 3,022 women in the UK Armed Services.
- 25% had a history of amenorrhea.
- 18% had oligomenorrhea or amenorrhea in the last 12 months.
- Women who slept >8 hours were at a lower risk for amenorrhea than women who slept <5 hours/night.
- Women who completed >10 hours of field exercise in the last 12 months were at higher risk for amenorrhea than those who did not complete field exercise.
- Women with history of disordered eating, anxiety, or depression were at a higher risk of having a history of amenorrhea.
- British servicewomen had a similar risk of amenorrhea to some female endurance athletes.

O'Leary et al., Frontiers in Nutrition, October 2022.

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How Low Is Too Low?

Energy Availability…

- Dietary intake minus exercise energy expenditure
- Amount of energy available to the body to perform all other functions after exercise training expenditure is subtracted

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Energy Availability Thresholds

- **45 kcal/kg fat-free mass/day** is recommended to maintain adequate energy for all physiological functions.
- **30-45 kcal/kg fat-free mass/day** is considered "reduced or sub-clinical energy availability." May be tolerated for short-term weight loss with appropriate dietary and exercise modifications.
- **<30 kcal/kg fat-free mass/day** is considered low energy availability and is considered unsafe; may lead to sports performance and health outcomes.

Logue, et al., Sports Med (2018) 48: 73

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Energy Availability – Calculating Recommended Energy Needs

Courtesy of M. Stockwell

- **Recommendation: 45 Kcal/kg fat-free mass**
- ***Example:*** 125-pound distance runner
- Body fat percentage = 15%
- Fat-free mass is 85% of 125 pounds = 106.25 pounds (**48.3kg**)
- 48.3 kg x 45 Kcal/kg = at least ***2,173*** Calories/day

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Energy Availability - *Reality*

Courtesy of M. Stockwell

- ***Example:*** 125-pound distance runner with 15% body fat = 106.25 pounds lean mass (48.3 kg)
- Dietary Intake = 2,800 Calories per day
- Exercise Expenditure = 600 Calories per day
- Energy Availability = 2,800 – 600 Calories = **2,200 Calories** / 48.3 kg = **45.5** Kcal/kg
- 45.5 Kcal/kg = **RECOMMENDED Energy Availability**
- 48.3 kg X 45 = at least ***2,173*** Calories/day

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Energy Availability – Calculating Recommended Energy Needs

- **Recommendation: 45 Kcal/kg fat-free mass**
- ***Example:*** 170-pound basketball player
- Body fat percentage = 20%
- Fat-free mass = 80% of 170 pounds = 136 pounds (61.8kg)
- 61.8 kg X 45 = at least ***2,781*** Calories/day

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Energy Availability - *Reality*

- ***Example:*** 170-pound basketball player with 20% body fat = 136 pounds lean mass (61.8 kg)
- Dietary Intake (DI) = 3,300 Calories per day
- Exercise Expenditure = 1,000 Calories
- Energy Availability = 3,300 – 1,000 = **2300 Calories** / 61.8kg = 37.2 Kcal/kg
- 37.2 Kcal/kg = **REDUCED** energy availability
- 61.8kg x 45 Kcal/kg = at least ***2,781*** Calories/day

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Energy Availability Category?

- **140-pound Irish dancer**
- **Dietary Energy Intake (DI) averages 2,200 Calories per day**
- **Exercise Energy Expenditure (EEE) = 800 Calories per day**
- **Body fat percentage: 8%**

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Calculate Energy Availability

- 140-pound Irish dancer with 8% body fat = _____FFM
- Energy Availability = DI-EEE / FFM
- 2,200 Calories (DI) – 800 Calories (EE) = (_____Calories) / ___ kg = _____ Kcal/kg/day
- Goal: at least 45 Kcal/kg/day FFM = at least _____Calories per day

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Energy Availability Category?

- 140-pound Irish dancer with 8% body fat = 128.8 pounds (**58.5kg**) FFM
- Energy Availability = DI-EEE / FFM
- 2,200 Calories – 800 Calories = **1,400 Calories** / 58.5kg = 23.9 Kcal/kg/day
- LOW ENERGY AVAILABILITY (<30)
- **Goal: at least 45 Kcal/kg**/day FFM = at least **2,632 Calories** per day

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Energy Availability Category?

MySwimPro / CC0

- 195-pound swimmer
- Dietary Energy Intake (DI) averages 4,000 Calories per day
- Exercise Energy Expenditure (EEE) = 1,300 Calories per day
- Body fat percentage: 12%

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Energy Availability Category?

- 195# swimmer with 12% body fat = _____ FFM
- Energy Availability = DI-EEE / FFM
- 4,000 Calories – 1,300 Calories (_____/ ____ kg = _____ Kcal/kg/day
- Goal: at least 45 Kcal/kg/day FFM = at least _____Calories per day

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Energy Availability Category?

MySwimPro / CC0

- 195-pound swimmer with 12% body fat = 171.6 pounds or **78kg** FFM
- Energy Availability = DI-EEE / FFM
- 4,000 Calories – 1,300 Calories = **2,700 Kcal** / 78kg = 34.6 Kcal/kg/day
- Goal: at least 45 Kcal/kg/day FFM = at least 3,510 Calories per day
- **REDUCED** Energy Availability

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RED-S Risk Assessment Screening

High Risk	Moderate Risk	Low Risk
• Disordered eating • Other serious medical conditions related to low energy availability • Extreme weight loss • Other life-threatening conditions	• Prolonged low body fat • Substantial weight loss (<5-10% of body mass/month) • Attenuation of expected growth/ development in adolescents • Abnormal menstrual cycle • Menarche >16 years old • Abnormal hormone profile in males • Reduced bone mineral density • History of stress fractures associated with hormonal/ menstrual dysfunction and/or LEA • Laboratory abnormalities • ECG abnormalities • Prolonged energy deficiency • Lack of progress in treatment or noncompliance	• Healthy eating habits with appropriate energy availability • Normal hormonal and metabolic function • Healthy bone mineral density • Healthy musculoskeletal system

Adapted from: Mountjoy, "Relative Energy Deficiency in Sport", ASPETAR Sports Medicine Journal, October 2015

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RED-S Return-to-Play Recommendations

High Risk	Moderate Risk	Low Risk
• No competition • No training • Use of written contract	• May train as long as the athlete is following the treatment plan • May compete once medically cleared under supervision	• Full sports participation

Adapted from: Mountjoy, "Relative Energy Deficiency in Sport", ASPETAR Sports Medicine Journal, October 2015

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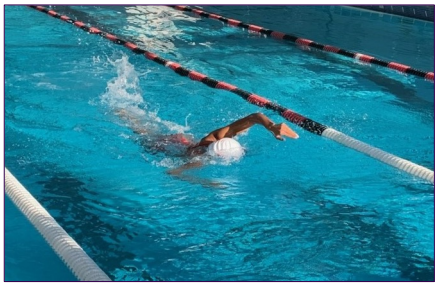
RED-S Treatment

- ***The treatment program for RED-S should focus on reversing low energy availability.***
- Treatment includes increasing dietary intake of energy and/or decreasing energy expenditure through limiting exercise intensity and quantity.



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RED-S Treatment

- Practical approach: Increase calories 300-600 per day.
- Add calories in small amounts around periods of exercise (pre-workout, during-workout, and post-workout).
- Focus on fluids.
- Increase bone-building nutrients (protein, calcium, Vitamin D).
- Address other health issues and any underlying psychological concerns.

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Assessment and Management – Sports Dietitians in Australia

55 Sports Dietitians in Australia were surveyed about their assessment and management practices when working with athletes at risk for low energy availability.

Athletes at risk most frequently presented with:
- Recurrent injury or illness (63%)
- Inability to meet daily energy requirements due to reduced dietary intake (63%)

Sports Dietitians most often assessed:
- Dietary intake (90%)
- Menstrual dysfunction (89%)
- Training load (75%)

Sports Dietitians most often monitored:
- Residual (ongoing) fatigue (96%)
- Training performance (92%)
- Recovery between sessions (92%)

Sports Dietitian practices for assessing and managing athletes at risk of low energy availability (LEA) Amy-Lee M. Bowler, Vernon G. Coffey, Gregory R. Cox

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Future Research Questions …

- What magnitude of increase in energy intake (EI) should be used to treat RED-S, and how should this increase in EI be distributed across a day?
- Does excessive exercise energy expenditure (EEE) raise the threshold of energy availability (EA) needed to maintain and/or restore reproductive health in female athletes?
- Can female or male athletes correct endocrine dysfunction by increasing EI to improve EA without any concurrent reductions in EEE?
- Does the macronutrient composition (i.e., carbohydrate vs. protein vs. fat) of increased EI make a difference in the treatment of RED-S?
- Does reducing fiber intake influence the hormonal health of female athletes with menstrual dysfunction?
- Can psychogenic stress reduction through cognitive behavioral therapy be used to treat endocrine dysfunction in athletes?
- What is the optimal daily intake of calcium needed to promote bone health in athletes?
- What is the best method of strength or resistance training for improving BMD in athletes with low BMD?

Kuikman et al., A Review of Nonpharmalogical Strategies in the Treatment of Relative Energy Deficiency in Sport, 2021.

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Take Home: Promote Healthy, Fit Bodies

- **Loss of menstruation is NOT a normal part of training.** It is, however, a possible **RED FLAG** to be aware of.
- Calorie (energy) intake must mirror training. If training increases in duration and/or intensity, increases in energy intake should follow. ***This should be an automatic expectation for athletes, parents, coaches, and the entire team working with athletes.***
- Adding ***MORE*** training and exercise is not necessarily a good thing. It can lead to overtraining and injuries.
- ***Encourage athletes to be the best they can be WITHIN their own bodies.***

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Keep these healthy athletes coming!

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Resources

- Sports and Human Performance Nutrition Practice Group of the Academy of Nutrition and Dietetics: https://www.shpndpg.org/educational-resources
- Collegiate and Professional Sports Dietitians Association: https://sportsrd.org/downloadable-resources/
- NCAA Sports Science Institute: http://www.ncaa.org/sport-science- institute/nutrition
- TEAM USA Nutrition: https://www.teamusa.org/nutrition

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Questions

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Upcoming Event

iStock photos

Increasing Children's Fruit and Vegetable Exposure: Tools for Practitioners Serving Families Experiencing Limited Income

Wednesday, March 1, 2023, 12:00-1:00 PM ET

This webinar will focus on nutrition for children affected by poverty and will discuss steps providers can implement to improve health and developmental outcomes for children in low-income families.

Continuing education credit will be available for this session!

OneOp.org/event/134982

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Continuing Education

This webinar has been approved for the following continuing education (CE) credits:

- 1.0 CPEU for RDNs and NDTRs from the Commission on Dietetic Registration
- Certificate of attendance

Evaluation Link

Go to the event page for the evaluation and post-test link.

Continuing Education

Questions?

Email Bethany Daugherty at OneOpNutritionWellness@gmail.com

OneOp.org/event/134985

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