



Understanding the Relative Energy Deficiency in Sports (RED-S)

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Introduction

The term RED-S first described by the International Olympic committee in the year 2014 [1] is the 'Relative Energy Deficiency in Sports' occurring as the consequences of altered physiological functioning causing abnormal metabolic rates, bone health changes, altered immunity and protein synthesis along with a compromised cardiovascular health and psychological health issues [2]. The condition of RED-S is believed to occur as a result of insufficient caloric intake and/or excessive energy expenditure.

In simpler words

Energy Expenditure > Energy Intake = Decreased Availability of Energy

The concept and the term RED-S is an advancement of the 'female athlete triad' which was an earlier identified term used for the syndrome observed among female athletes with signs of low energy availability, menstrual dysfunction (amenorrhea/oligomenorrhea) and low bone mineral density [1]. The revision of the name emphasizes the occurrence of the condition is also seen in active men in sports [1]. RED-S is considered as a serious and life-threatening illness among athletes [3]. As the condition is found to be an inter-connection between three conditions, it is believed that if an athlete shows the signs of one element of the triad, it is likely for them to be suffering from the other two elements of the triad as well [4]. It is also highlighted in some studies that in order

for an athlete to be suffering from the condition, the presence of all three elements is not necessary to make the diagnosis, identification of single element can also lead to further investigations in the direction of ruling out RED-S [5,6]. Female Athlete Triad Coalition Consensus Statement on treatment and return to play of the female athlete triad: 1st International Conference was held in San Francisco, California, May 2012 and 2nd International Conference held in Indianapolis, Indiana, May 2013 [7].

The female athlete triad

The concept originated to work on a female athlete's triad to understand the inter-relationship between energy availability, menstrual function, and bone health. The disorder was first coined by the American College of Sports Medicine in the year 1992 after witnessing a trend of menstrual abnormalities, eating disorders and low bone mass density among youth and adolescent female athletes [8].

The prevalence of amenorrhea was accounted to be 69% in female athletes as compared to the non-athletic females with a prevalence of 2%-5%. Eating disorders like such as, anorexia nervosa and bulimia nervosa were also identified among female athletes involved in sports emphasizing leanness to reduce weight before competitions. The prevalence of eating disorders among female athletes ranged from 16%-47%, variable as per the type of sports, training, screening methods, age, etc. The prevalence of bone-related disorders like osteopenia ranges from 22%-50% and osteoporosis prevalence of 0-13% [8].

The advancements were made in the research later and it was identified that the concept cannot only be used for the relationship between three factors but also other physiological and health related factors causing impaired functioning in the body. It was also identified that the concept can be used for both male and female athletes. And hence the conceptual definition was later proposed in 1997 [8].

Pathophysiology

Low energy availability results in altered hormonal pathways affecting release of hormones in the body such as thyroid hormone signaling pathways, altered metabolism of carbohydrates, abnormal leptin levels, growth hormones, insulin-like growth factor-1 axis, also affecting sympathetic and parasympathetic tone.

As a result of reduces energy levels in the body, there occurs decreased levels of release of gonadotropin-releasing hormones impairing anterior pituitary release of gonadotropins. In female body, hypoestrogenism occurs as a result of reduced release of FSH and LH hormones. This results in functional hypothalamic amenorrhea and a decreased bone mass. In male body, it has resulted in a deteriorating bone health due to reduced testosterone levels [8,9].

RED-S in male athletes

While there are few reports on the incidence of low energy availability in male athletes, it is found that male cyclists had a severely reduced energy availability of 8 kcal/kg/FFM/day, and male runners had a severely reduced energy availability of 8 kcal/kg/FFM/day. Although male athletes are less likely to develop RED-S, the prevalence is high in Cycling (50%) which is the most popular sport, followed by gravitational sports (24%) and weight-class sports. (18%) [7].

Consequences of RED-S on health and performance in athletes

- **Menstrual health:** The absence of regular menstrual cycles without any identified organic causes is known as functional hypothalamic amenorrhea (which is common in athletes with Low Energy Availability). This is due to gonadotropin-releasing hormone (GnRH) pulsatility being suppressed, resulting in low or low-to-normal levels of luteinizing hormone (LH) and follicle-stimulating hormone (FSH), yet the gonadotropin response to GnRH stimulation is retained [9,10].

- **Cardiovascular health:** Increased LDL, HDL, triglycerides. Impaired endothelial function, vascular resistance. Altered renin-angiotensin-aldosterone response causing low heart rates and systolic blood pressure. Other effects are bradycardia, hypotension, valve abnormalities, arrhythmia, pericardial effusion etc [10].
- **Metabolic bone health:** Major changes in bone health are the proliferation and bone formation, altered repair mechanism, increased risk of fracture. Decreased osteoclasts and osteoblasts, IGF-1 stimulation of osteoblast genesis and bone formation leptin and T3 proliferation of osteoblast [9,11].
- **Psychological health:** Disordered eating combined with a lack of energy has major psychological consequences, including depression, low self-esteem, and anxiety [8].

Clinical Features [1]

Historical elements to be identified

- **Medical history:** Dietary changes, body weight changes, sleep disturbances, exercise pattern and types, hours of training, menstrual cycle, injury, fractures.
- **Family history:** Eating disorders, reproductive disorders.
- **Psychological:** Mood, stress, anxiety, social approval, ambitions and expectations, pressure.
- **Personal history:** Smoking, alcohol, substance abuse.

Physical Signs

- **Built:** Height, weight, BMI, orthostatic blood pressure, percentage of body fat.
- **Eating disorder:** Lanugo, parotid gland enlargement, hypercarotenemia, Russell's sign.
- **Cardiac:** Bradycardia, arrhythmia.
- **Mucus membrane:** Pale and dry.
- **Skin:** Acne, male pattern hirsutism.

Screening and diagnosis

When an athlete comes with weight loss, lack of normal growth and development, menstrual dysfunction, recurring accidents and illnesses, decreased performance, or mood changes, RED-S screening should be considered and should also be done as part of an annual Periodic Health Examination (PHE) [7].



Figure 1: Potential Performance Effects of Relative Energy Deficiency in Sports (*Aerobic and anaerobic performance) [7].



Figure 2: Health Consequences of Relative Energy Deficiency in Sport showing an expanded concept of the Female Athlete Triad to acknowledge a wider range of outcomes and the application to male athletes (*Psychological consequences can either precede RED-S or be the result of RED-S) [7].

The RED-S Clinical Assessment Tool (CAT) [12].

The RED-S CAT is a clinical assessment tool used to evaluate athletes and active players who are suspected of having relative energy deficiency and to guide return-to-play decisions. The RED-S CAT is intended for medical professionals to use in the clinical evaluation and management of athletes who have this illness. The tool is based on the 2014 ioc RED-S Consensus Statement.

This tool may be freely replicated in its current state for usage by organizations and athlete medical teams. However, the International Olympic Committee must approve any changes to the instrument or its reproduction for publication.

The Risk Assessment Model [12]

Since the symptoms of RED-S might be inconspicuous, screening and diagnosis can be difficult. A special attention on at-risk athletes is required. The risk assessment model for sports injury can be incorporated in the period health examination.

HIGH RISK: NO START RED LIGHT	MODERATE RISK: CAUTION YELLOW LIGHT	LOW RISK: GREEN LIGHT
<ul style="list-style-type: none"> - Anorexia nervosa and other serious eating disorders - Other serious medical (psychological and physiological) conditions related to low energy availability - Use of extreme weight loss techniques leading to dehydration induced hemodynamic instability and other life threatening conditions. 	<ul style="list-style-type: none"> - Prolonged abnormally low % body fat measured by DXA* or anthropometry - Substantial weight loss (5–10% body mass in one month) - Attenuation of expected growth and development in adolescent athlete 	<ul style="list-style-type: none"> - Appropriate physique that is managed without undue stress or unhealthy diet/exercise strategies
	<ul style="list-style-type: none"> - Low **EA of prolonged and/or severe nature 	<ul style="list-style-type: none"> - Healthy eating habits with appropriate EA
	<ul style="list-style-type: none"> - Abnormal menstrual cycle: functional hypothalamic amenorrhea > 3 months - No menarche by age 15y in females 	<ul style="list-style-type: none"> - Healthy functioning endocrine system
	<ul style="list-style-type: none"> - Reduced bone mineral density (either in comparison to prior DXA or Z-score < -1 SD). - History of 1 or more stress fractures associated with hormonal/menstrual dysfunction and/or low EA 	<ul style="list-style-type: none"> - Healthy bone mineral density as expected for sport, age and ethnicity - Healthy musculoskeletal system
<ul style="list-style-type: none"> - Severe ECG abnormalities (i.e. bradycardia) 	<ul style="list-style-type: none"> - Athletes with physical/psychological complications related to low EA+/-disordered eating; - Diagnostic testing abnormalities related to low EA +/-disordered eating 	
	<ul style="list-style-type: none"> - Prolonged relative energy deficiency - Disordered eating behavior negatively affecting other team members - Lack of progress in treatment and/or non-compliance 	

* dual energy X-ray absorptiometry
 **EA: Energy availability=Energy intake – Energy cost of exercise (additional energy expended in undertaking exercise).

Figure 3: RED-S Risk Assessment Model for Sports Participation [12].

Prevention and treatment strategies

A multidisciplinary athlete health support team, including a sports physician, nutritionist, psychologist, physiotherapist, and physiologist, should be identified. The medical staff must be educated on how to recognize and treat the RED-S [7]. Preventative educational programmer must be implemented, rule modifications/changes to address weight-sensitive concerns in sport must be addressed and policies for coaches on how to manage player eating behavior, weight, and body composition in a healthy manner should be implemented [7]. Educational programmes on RED-S, proper nutrition, energy availability, dieting concerns, and their impact on health and performance must be conducted [7].

The following techniques can be implemented by the athlete's team to prevent RED-S

- Reduced emphasis on weight, with a greater emphasis on nutrition and health as a means of improving performance.
- Development of attainable and health-promoting weight and body composition targets.
- Use of credible sources of information and avoidance of unfavorable comments about an athlete's body shape/weight.
- Promotion of the idea that good performance does not always imply good health.
- Encourage and encourage therapy that is appropriate, timely, and successful.

Athletes in the red and yellow zones as per the risk assessment model (Figure 3) should be evaluated and treated by a physician. A team of health specialists should treat RED-S, including a sports medicine physician, sports nutritionist, exercise physiologist, athletic therapist or trainer, a sports psychologist or sports psychiatrist. The goal of treatment should be to repair the relative energy deficit by increasing energy intake and/or lowering energy production. Nutrient and vitamin intake should follow recognized norms. Bone mass density should be measured again every 6-12 months, depending on the clinical presentation and baseline levels [7,12].

Return to Play

Decision-making concerning return-to-play (RTP) after time away from sport following injury or sickness recovery based on an evaluation of the athlete's health and the demands of his or her sport [12].

Bibliography

1. Elliott-Sale KJ., *et al.* "Endocrine effects of relative energy deficiency in sport". *International Journal of Sport Nutrition and Exercise Metabolism* 28.4 (2018): 335-349.
2. Statuta SM., *et al.* "Relative energy deficiency in sport (RED-S)". *British Journal of Sports Medicine* 51.21 (2017): 1570-1571.
3. Hobart, JA; Smucker. "The female athlete triad". *American Family Physician* 61.11 (2000): 3357-3367.
4. "What is the Triad?". Female Athlete Triad Coalition (2012).
5. Nattiv A., *et al.* "American College of sports medicine, American college of sports medicine position stand: female athlete triad". *Medicine and Science in Sports and Exercise* 39.10 (2007): 1867-1882.
6. De Souza MJ., *et al.* (2014).
7. Mountjoy M., *et al.* "The IOC consensus statement: beyond the female athlete triad-relative energy deficiency in sport (RED-S)". *British Journal of Sports Medicine* 48.7 (2014): 491-497.
8. Nazem TG and Ackerman KE. "The female athlete triad". *Sports Health* 4.4 (2012): 302-311.
9. Dipla K., *et al.* "Relative energy deficiency in sports (RED-S): Elucidation of endocrine changes affecting the health of males and females". *Hormones* 20.1 (2020): 35-47.
10. Coelho AR., *et al.* "The Female Athlete Triad/Relative Energy Deficiency in Sports (RED-S)". *Revista Brasileira de Ginecologia e Obstetrícia*, 43 (2021): 395-402.
11. Hotta M., *et al.* "The relationship between bone turnover and body weight, serum insulin-like growth factor (IGF) I, and serum IGF-binding protein levels in patients with anorexia nervosa". *The Journal of Clinical Endocrinology and Metabolism* 85.1 (2022): 200-206.
12. Mountjoy M., *et al.* "RED-S CAT™". *British Journal of Sports Medicine* 49 (2015): 421-423.