

# Relative Energy Deficiency in Sports (RED-S)

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## Relative Energy Deficiency im Sport (RED-S)

### Summary

- ▶ **This overview intends** to show a possible diagnostic/treatment pathway for athletes with an energy deficiency. This is based on the IOC statement paper (13), which was recently revised in 2023. An interdisciplinary approach is important to reach all aspects.
- ▶ **In order to achieve a successful treatment**, it is important to involve the whole environment of the affected athlete. The earlier the intervention takes place, the less chronic consequences will occur.
- ▶ **However**, abnormalities such as primary and secondary amenorrhea, susceptibility to infection or lack of training success should always be considered as possible indications and should be subject to further examination.
- ▶ **In addition**, it is also important to recognize a current or incipient eating disorder so that professional treatment can be initiated as soon as possible with the primary goal of enabling the athlete to train and compete at the highest level.

### KEY WORDS:

Amenorrhea, Psychological Abnormalities, Competitive Sports, Hormones, Training, Treatment, Interdisciplinary, Eating Disorders

### Introduction

Several years ago, the term female athlete's triad was replaced by the symptom complex of relative energy deficiency in sport (RED-S). It has been shown that a prolonged energy deficit can lead to far reaching symptoms and health consequences in both men and women involving multiple organ systems (figure 1). The term female athlete's triad, which was previously used, does not entirely capture the extent of the endocrinological and metabolic disorders that a low energy availability (LEA) can produce. It is important to emphasize that LEA does not always have to be accompanied by an eating disorder. The symptoms can be manifold, including gynecological symptoms, recurrent and prolonged infections, stress fractures, and others (figure 1). They can vary considerably between individuals, complicating diagnosis, and initiation of adequate treatment. A testosterone deficiency in men can also occur as a symptom. Athletes in some sports, such as aesthetic sports, endurance sports, and weight-bearing sports, certainly have a higher potential to suffer from LEA than others. LEA is defined as an imbalance between energy consumption and energy intake. The transition from acceptable LEA to problematic LEA or even an eating disorder can be gradual (1). In female athletes, it is generally assumed that an energy intake of less than 30 kcal/kgFFM per day can promote the occurrence of RED-S. In male athletes, this has not yet been carefully investigated and it is assumed that an intake of less than 25 kcal/kgFFM might be the cut-off point (1). Even short times of LEA can produce

symptoms of RED-S which is important in weight-class sports. In this case, it is necessary to know the differences between an adaptable LEA and a problematic LEA (13).

A major challenge in the diagnosis of RED-S is the discrimination from overtraining syndrome, which can lead to similar symptoms (13).

To avoid long-term health sequelae beyond the athletic career, every suspected RED-S has to be diagnosed and treated within an interdisciplinary team, including sports medical doctors, gynecologists, endocrinologists, nutritionists, and psychologists, as well as the athlete themselves and relevant stakeholders (i.e. coaches, family, peers). For several years, a working group at the IOC has regularly developed statement papers and assessment tools (13). Based on their recommendations and existing evidence, the RED-S syndrome will be briefly explained in the following and a recommendation for action will be given.

### The Clinical Picture of RED-S

Visits to the sports medicine outpatient clinics or the annual examinations for sports fitness, offer the opportunity to identify abnormalities in athletes that may be suggestive of LEA. Recurrent infections or a lack of regeneration including chronic exhaustion could be the first signs. Here, it is important to take a detailed medical history, as well as to assess current and chronic dietary and

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Table 1

Determination of the individual risk and thus determination of the further procedure.

INDIVIDUAL RISK	PROCEDURE
Very high risk	No permission to exercise, direct treatment
Moderate/high risk	Sports clearance with restrictions and close monitoring
Low risk	Clearance with monitoring
No/very low risk	Clearance

Table 2

Check list for gynecological history.

INDICATORS	
Puberty	Psychological – delayed – stagnating?
Menarchy	Spontaneously?
Menstrual cycle pattern	Regular – irregular – disturbances – heavy bleeding?
Contraception	Yes / No
Current or past use of hormones	Therapy and / or contraceptive
Pregnancy / wish for children	Yes / No
Symptoms of hormone deficiency	Yes / No

training habits. This includes calorie intake and the acute and chronic training load. Ideally, a food diary should be available for at least 3 - 5 days to correlate training load with diet. Specific questions should ask about the female cycle, stress fractures, sleep patterns, and any psychological changes, such as depressive or aggressive mood, lack of motivation, and the feeling of insufficiency. In male athletes, a sexual history (e.g. libido, erectile dysfunction, infertility) should also be obtained, if RED-S is suspected. In addition, a physical examination should be carried out, and attention should also be paid to the presence of secondary characteristics, such as lanugo hair or hair loss. The next step should be an anthropometric assessment of Body Mass Index (BMI) and body composition via Caliper measurement and bio-electrical impedance analysis (BIA) measurement. In the knowledge about the problems of the BIA measurement of people having low body fat. Blood pressure, resting pulse and resting ECG should be obtained to detect hypotension, pathological bradycardia (<30 bpm and symptomatic) (7) or Long-QT, which are high risk conditions and require immediate suspension of training and competition. Laboratory examinations should include the detection of electrolyte disturbances, like hypokalemia or hyponatremia, TSH, fT3 and fT4 status, cortisol, growth hormone, Insulin-like growth factor 1, progesterone, luteinizing hormone, follicle stimulating hormone, and testosterone to detect suppressions of the respective hormonal axes. Furthermore, a differential blood count and micronutrients, including ferritin, as well as vitamin D should be determined as immediate treatment of deficiencies is indicated in all athletes. Further examinations should be performed, if indicated as early as possible, and within the respective specialist disciplines (6).

The IOC provides a diagnostic tool based on a three-step approach for initial decision-making of the following procedure (figure 2).

### Step 1 – Screening with Questionnaires and Medical History

### Step 2 – Risk Assessment (According to IOC RED-S CAT 2) (13)

#### Primary Indicators

- Amenorrhea (primary or secondary)
- Eating disorders
- Osteopenia/stress fractures (high risk or >2 low risk)
- Hormone changes (T3 and/or testosterone reduced)
- Growth abnormalities

#### Secondary Indicators

- Oligomenorrhea
- Stress fracture (1 low risk)
- Elevated cholesterol/LDL
- Depression/anxiety

Determination of the individual risk and thus determination of the further procedure using the RED-S CAT 2 Calculator Tool on Microsoft Excel (1, evaluation based on a traffic light system, table 1).

### Step 3: Multidisciplinary Diagnosis and Treatment

According to the traffic light model it is possible to discuss the following steps with the athlete and their stakeholders. It is important to know that the first therapeutic option in the treatment of the RED-S is to compensate for the energy deficiency as soon as possible by reducing or stopping exercise and commencing a stepwise normalization of dietary habits. Endocrinological abnormalities require pharmacological treatment (1). Experience shows that good cooperation can achieve the fastest success (4, 18).

### Gynecological and Endocrinological Implications

There are various forms of menstrual disturbances that may occur in women with RED-S. The most evident one is amenorrhea (no menstrual bleeding for at least three months). Also, oligomenorrhea (menstrual cycles longer than 35 days) can be associated with adverse effects on bone health (5). LEA decreases GnRH-pulsatility and consecutively leads to reduced serum levels of gonadotropins (LH and FSH). So, the typical clinical finding is a functional hypogonadotropic hypogonadism or functional hypothalamic amenorrhea (FHA) with low estradiol and progesterone levels (9).

FHA is a diagnosis of exclusion (9). Work - up for amenorrhea in athletes involves a complete medical history, especially about puberty and menstrual cycle patterns, a pelvic examination (including sonography), a pregnancy test, and a hormone profile to rule out other endocrinopathies, such as hyperandrogenemia, hypothyroidism, hyperprolactinemia, and premature ovarian failure.

A more extended work - up is necessary in athletes with primary amenorrhea, defined as no menstrual bleeding until the age of 16. Although RED-S is associated with delayed puberty in both sexes (2), other reasons for primary amenorrhea need to be excluded. The examination should emphasize puberty signs (Tanner stages for breast development and pubic hair) and genital anatomy. Other reasons for primary amenorrhea are obstructive genital malformations, uterine aplasia, disorders of sex development or genomic alterations.

If FHA as a sequela of LEA is confirmed, the primary goal of first - line therapy is to reestablish a slightly positive ener-

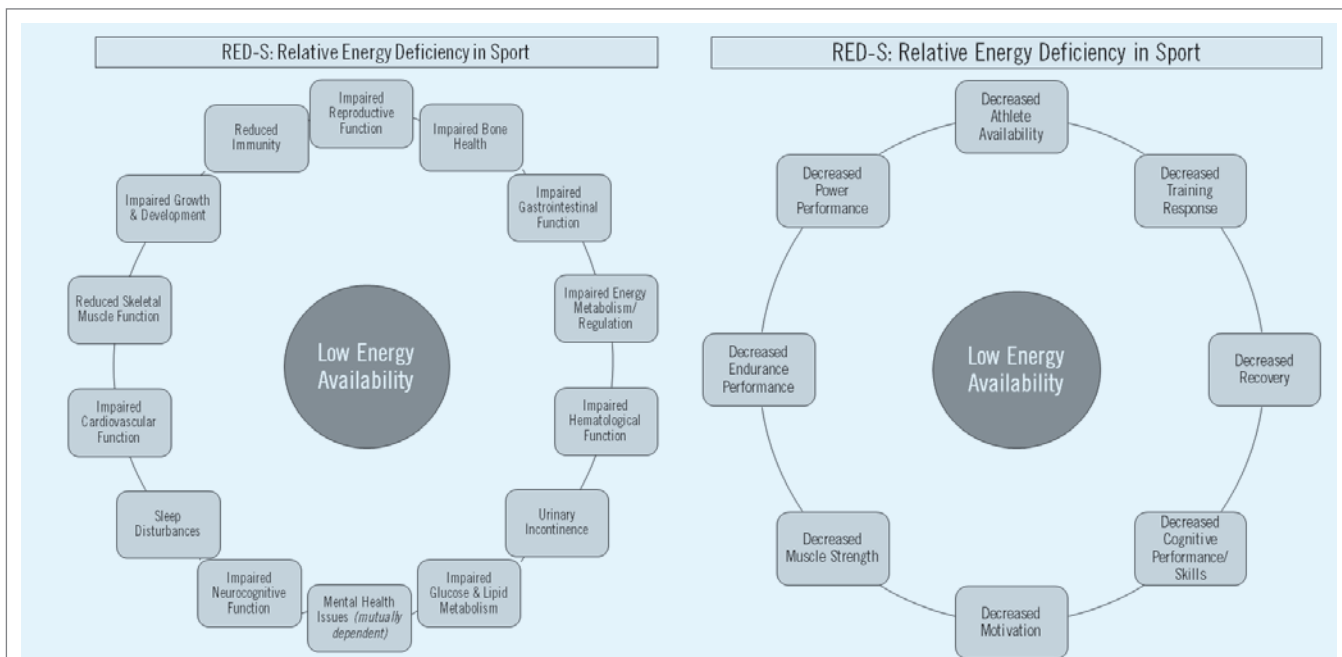


Figure 1

Left: The RED-S Health Conceptual Model (13), modified by (16). Right: The RED-S Health Conceptual Model (13), modified by (16).

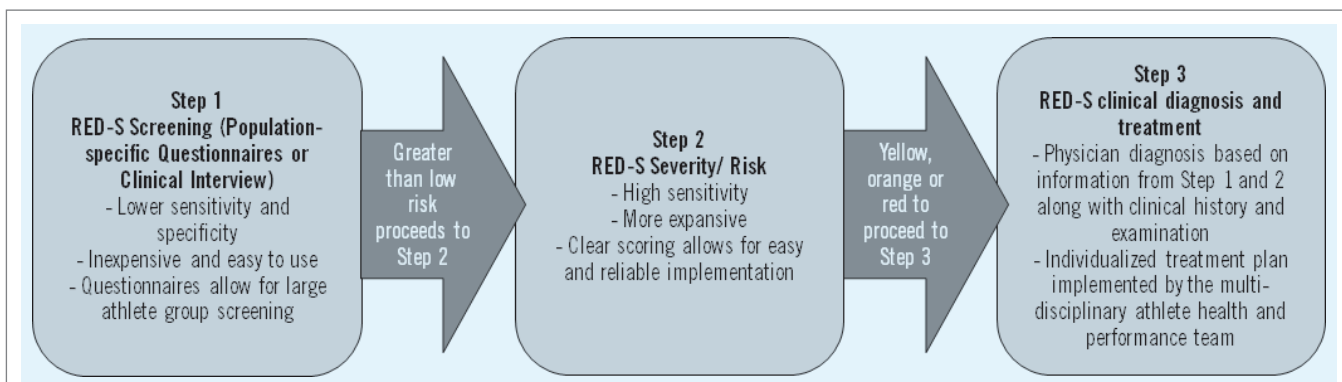


Figure 2

Treatment and clinical assessment tool 2 (IOC RED-S CAT2) (13) modified by (16).

gy balance. Therefore, the most important measures are the suspension of training and competition, as well as the stepwise reestablishment of an adequate intake of calories and carbohydrates. Further therapeutic measures based on individual necessities can be implemented. For example, in patients with persisting amenorrhea and a history of fractures and/or low bone mineral density, hormone replacement therapy can enhance bone mineral density (5). It is important to note, that this effect has been shown only for transdermal estrogen therapy in combination with cyclic oral micronized progesterone. Instead, the contraceptive pill had no effect on bone mineral density (9). Nevertheless, patients should be counseled about contraception, if needed.

In patients with RED-S associated delayed puberty, a stepwise hormonal induction of puberty may be necessary. The pill must not be used in these cases to induce menarche, as this carries the risk of premature termination of uterus maturation, potentially reducing fertility in later life. Delayed puberty in patients with RED-S needs an individual regimen. So far, no evidence exists about pharmacological treatments in this special group.

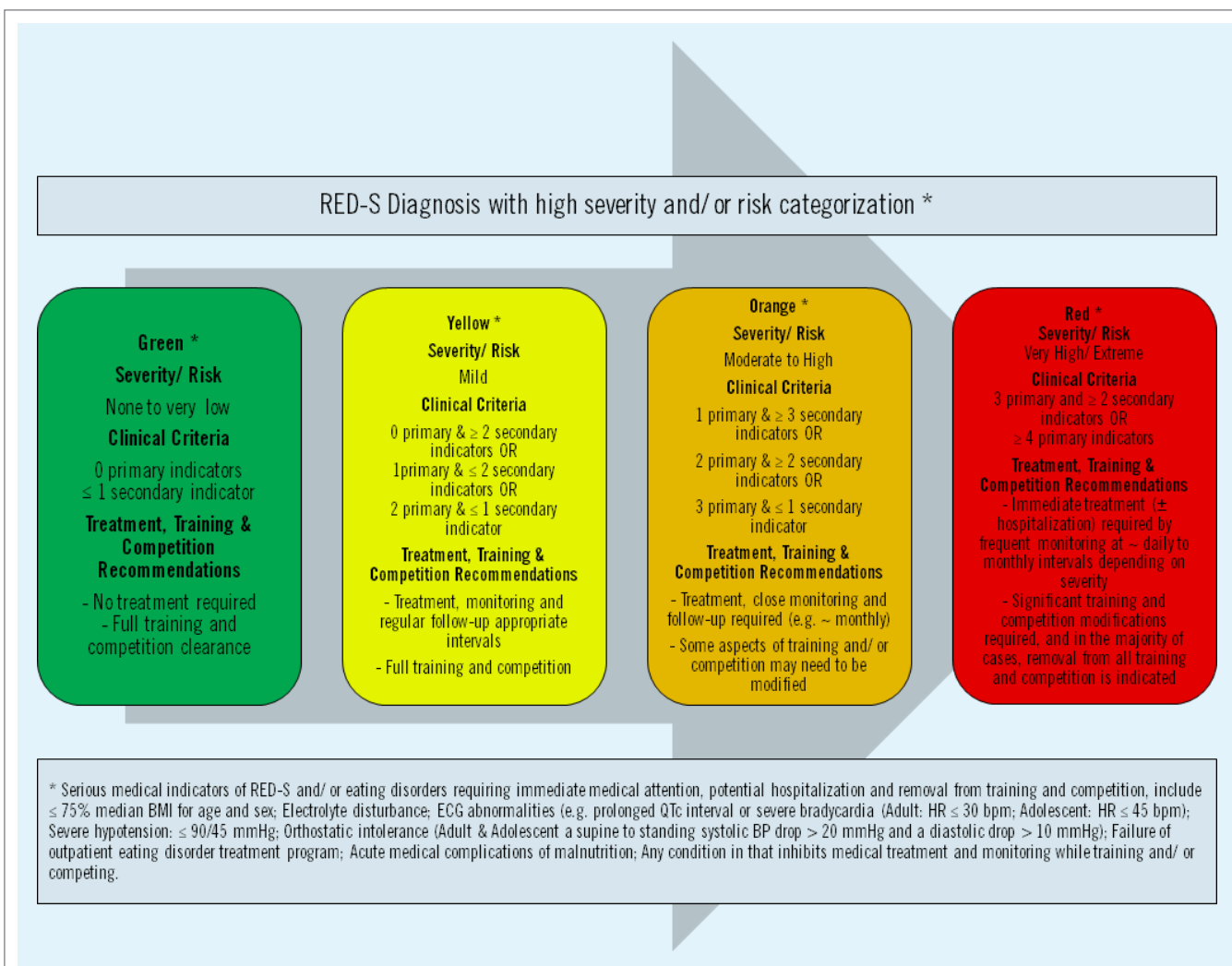
A relevant number of patients remains amenorrhoeic even after training reduction and weight normalization. In these ca-

ses, the individual threshold of acute and chronic LEA below which amenorrhea and a low BMI result may persist even after suspension of training. Regular contact with the interdisciplinary team is necessary here.

In male athletes, LEA can be associated with reduced testosterone levels. However, a possibly non-pathological exercise-related hypogonadal male condition (EHMC) is an important differential diagnosis that should be considered (10). However, distinction of LEA and EHMC is difficult because symptoms show a large degree of overlap. Typically, in EHMC no osteopenia and stress fractures occur. Treatment of LEA and EHMC differs, as EHMC mainly focuses on the reestablishment of a stress/recovery balance in training, whereas dietary habits are typically normal and no dietary intervention is necessary (table 2).

### Psychological Aspects

Excessive physical activity can be associated with eating disorders or disordered eating, either to avoid weight gain or in terms of emotion-regulating behavior. Eating disorders can cause lasting damage to physical and mental health and even lead to premature >



**Figure 3**  
RED-S CAT 2 Calculator Tool (IOC RED-S CAT2) (13), modified by (16).

death (3). Athletes show an increased risk of developing pathological nutrition-related attitudes or behaviors, such as body dissatisfaction, disturbed eating patterns or disordered weight-control behaviors, or even a full-syndrome eating disorder (8,12).

If an eating disorder is assumed as the cause of LEA, psychotherapy should be part of the treatment schedule. An early implementation of eating disorder-specific psychotherapy can significantly improve the likelihood of a successful outcome (11).

**Special Issues from the Perspective of Child and Adolescent Psychiatry**

In Child and Adolescent Psychiatry, Psychosomatics and Psychotherapy, the involvement of parents is particularly important for the assessment of suspected RED-S and / or eating disorders. Parents should be involved from the beginning and throughout the entire process of diagnostic assessment and treatment. They need to be informed about the current situation, and further treatment options, need to be encouraged to support their children in regaining healthy eating habits, and to be guided on how to do so. Both, children and parents need to be informed about healthy eating habits that match their personal energy needs, including the number and size of meals and sufficient amounts of macro- and micronutrients. The minimum weight is determined together with the patient and based on age- and sex-specific percentiles. When calculating the minimum weight,

the percentiles of the BMI trajectory before the illness are taken as a basis. In the case of BMI trajectories above the 25th percentile, the 25th percentile should be defined as the target. In the case of pre-illness BMI trajectories below the 25th percentile, a percentile corresponding to previous values should be selected as the therapeutic target. A body weight below the 25th percentile could lead to difficult spontaneous conception with the need for hormonal support due to prolonged amenorrhea or cycle irregularities. In the case of inpatient treatment, sport and exercise should be recommenced to enable patients to develop a feeling for their energy requirements when exercising.

**Centre of Excellence for Eating Disorders Tübingen (KOMET)**

Centre of Excellence for Eating Disorders Tübingen (KOMET) The Centre of Excellence for Eating Disorders Tübingen (Kompetenzzentrum für Essstörungen Tübingen, KOMET) is the first university-based multidisciplinary competence centre in Germany that focuses on eating disorders across the lifespan. In case of a suspected eating disorder (mostly anorexia nervosa) in association with LEA / RED-S, athletes are referred to the departments of Child and Adolescent Psychiatry, Psychosomatics and Psychotherapy or Psychosomatic Medicine and Psychotherapy respectively. Depending on the severity of the eating disorder and/or possible comorbid psychological conditions (i.e. depression or anxiety disorder), psychotherapy is

recommended as the method of choice (3). In the future, such multidisciplinary centres should also be established at other locations in Germany.

### Prevention of LEA

Awareness and knowledge about a condition called RED - S and associated symptoms are the most important preventive factors. Coaches, athletes, parents, and the social environment should be informed and educated about the disease. Studies have shown that only a small number of coaches demonstrate sufficient awareness and knowledge about RED-S (17). Recognition of suspicious symptoms and involvement of a medical doctor should happen as early as possible. Screening and education of athletes, coaches, support staff, and parents using questionnaires and simple assessment tools (for example LEAF Q LEAM Q) may be helpful in this context (3).

In sports where the risk is known to be high, preventive advice works best, if given at an early stage of an athlete's career including sport-specific nutritional education.

LEA and RED-S in male athletes are still underrecognized, so it is important to raise awareness of these conditions among the athletes, coaches, and their social environment. Finally, para-athletes can also be affected of LEA and RED-S, as they have an increased risk of insufficient energy intake due to disability, large variations in energy expenditure during exercise, and rest and potential dietary restrictions. Few studies have been carried out in this area to date complicating assessment and treatment.

### Conclusion

In order to avoid short- term, as well as long-term health consequences, attention should be paid to early symptoms of LEA / RED-S in athletes, such as an abnormal susceptibility to infections, recurrent stress fractures, hypothyroidism and other hormonal imbalances, mismatch of training effort and performance development, low levels of testosterone, primary or secondary amenorrhea, delayed growth or onset of puberty, depression, and anxiety. An early intervention, in an interdisciplinary network, may reduce the duration of suspended training, improve chances of a successful return-to-competition, and mitigate short- and long-term health consequences. However, it is important to distinguish between an energy deficit and a manifest eating disorder, as in the latter case, psychotherapy should be an integral part of therapy. Current IOC recommendations provide a structured approach to the diagnosis and treatment of LEA and RED-S in athletes (13). ■

### Conflict of Interest

*The authors have no conflict of interest.*

### Data Sharing

*All data used on RED-S CAT 2 Calculator Tool on Microsoft Excel are available by scanning the QR Code in the online supplement.*

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