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Identifying and promptly attending RED S in athletes

Paulina Navarro Torres Arpi, MD,

Juan Gabino Gomez Mont, MD

Félix Gil-Orbezo, MD Prof.

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Relative Energy Deficiency in Sports (RED S)

- **“Impaired physiological functioning status caused by relative energy deficiency in athletes causing all kinds of metabolic, functional and performance anomalies”** - IOC 2014 [1]
- Athletes in leaner sports have higher risk (up to 80-100%) [3][6][8][9]
- 32.98% of college athletic trainers have heard of RED-S [12]
- Intake of < 30 kcal/ kg could start to show some metabolic adaptations
- Recommended intake >45 kcal/kg in females and >40 kcal /kg in men. [3][14][15][16][17][18]
- In 65% of athletes that spend more time in an energy deficit below 400kcal present adaptation in basal metabolic rate [18]

Effects of Low Energy Availability (LEA)- Montjuy 2014

Hematological	Low iron levels decrease metabolic efficiency increasing energy requirements during rest and exercise, affecting bone metabolism, contributing to an hypoxic state[13] [27] Impairs aerobic power negatively [28][29]
Endocrine	Alters the normal release of hypothalamic-pituitary axis hormones, thyroid function (euthyroid sick syndrome specifically has been well reported in females) and leptin secretion[10] [3] At 30 kcal/kg 40% of females became amenorrheic and males had low testosterone levels; these athletes had significantly lower sex hormones, T3 concentrations and 4.5 times greater incidence of bone injuries [15] [3] More research is needed on the pathologic changes in the hypothalamic -pituitary-thyroid axis [10]
Metabolic	Energy preserving mechanisms such as diminishing reproductive and thyroid function [3] There is a relation between LEA and endothelial dysfunction, lipid profile and gastrointestinal alterations [3]
Bone health	MECHANIC: The strength remodeling and bone structure is a dynamic equilibrium between mechanical load and rest and recovery, without it it will suffer an overuse or traumatic injury. [20] HORMONAL: Hypoestrogenism suppress osteoclast activity [10] After endurance training testosterone concentrations fall and exacerbated by LEA looses its inhibitory effect on bone resorption [22] Lower levels of Vit D increase the change of injury, muscle function and immunity, and it has a synergistic role with testosterone when related to lower BMD in lumbar spine in cyclists [22] STRESS FRACTUES: Risk factors: Low testosterone, BMI <17.5 kg/m2, <85% of expected body weight, >10% of weight loss in 1 month [3]

Growth & development	By 18 years of age 90% of peak bone mass must be achieved to avoid added fracture risk later in life and promote optimal bone health, more research is needed to better understand growth complications related to LEA [13][30][31]
Psychological	Higher Ineffectiveness, Asceticism, Impulse Regulation, and Social Insecurity subscales, on the EDI-2, Awareness, and Impulse Regulation scores, anxiety, depression, compulsive disorders, efficacy, introspective, conscience, impulse control , eating disorders [3][5]
Immunological	Lower levels of secretory immunoglobulin A with higher incidence of upper respiratory tract and gastrointestinal infections [26]
Cardiovascular	Amenorrheic athletes have impaired flow mediated dilation associated to atherosclerosis, this hypo estrogenic state is comparable to postmenopausal women concerning coronary vascular disease (elevated LDL, triglycerides and cholesterol) and endothelial dysfunction **[10][12]** Negative relationship between testosterone and cardiovascular disease has been described while associated with reduce myocardial function **[31]**
Reproductive Function	Female: It suppresses pulsatile GnRH secretion, which impairs the release of the gonadotropins, FSH and LH further reducing production of estradiol in the ovaries· **[10]** Male: Exercise-Hypo gonadal Male Condition (EHMC) is low or low normal testosterone with an inappropriately low luteinizing hormone (secondary hypogonadism)**[10]** Excessive training load suppresses the HPA therefore suppressing LH and testosterone, self-reported libido and sexual drive; all not necessarily related to energy deficit **[3][10]**
Gastrointestinal	Alterations described with concomitant eating disorders, altered sphincter function, delayed gastric emptying, constipation and increased intestinal transit time [13] [32]

Screening for LEA and RED –S

- 7.4% of international olympic federations have prevention, guidelines, activities or screening programs for RED-S [33]
- Care must be specially taken in sports that emphasize leanness before competition, calorie restriction, eating disorders, menstrual disorders and stress injuries [3] [15]
- Athletes have the same right to human dignity, physical and psychological well being, health and safety[3][7][11]
- LEA affects performance by, increasing recovery period, decreasing training response, impairing judgment, decreasing coordination and concentration, irritability, depression, decreasing endurance; premature reduction in physical, mental and psychological capabilities, muscle mass and function[13][39]
- Needs an interdisciplinary team of sports psychologist, nutritionist, trainers and team physicians [3][14]
- Careful timing of energy and fuel availability around training is important to combat metabolic stress [41]
- Pondered weight gain (5-10%) increasing by >360kcal/day and decreasing training load by one day could reestablish adequate reproductive and endothelial function, BMD and balance the hormone and adaptive response in 1.5-2.6 months [14]

TOOLS

- Complete history: delayed menarche (>**15** years), oligo or amenorrhea (>35 days or >90 days), stress fractures or bone stress reaction, frequent viral infections must be obtained. [32]

- Abnormal scores in at least 2 questionnaires classifies an athlete as “at risk” or suffering of LEA [39]

Questionnaires

- BEDA-Q (Brief Eating Disorder in Athletes Questionnaire) [38]
- ESP (Eating Disorder Screen for Primary Care)[39][44]
- SR(Self-reported current or past history of eating disorder).[38]
- REDS-CAT (Relative Energy Deficiency Syndrome - Clinical Assessment Tool) [3][13][46]
- LEAF-Q (Low energy availability in females questionnaire) [3][44][45]
- LEAM-Q (Low Energy Availability in Male Athletes Questionnaire LEAM-Q) [3][13][46]

Measurements

- Lean body mass (fat free mass + essential fat). (10)
- Resting metabolic rate ≤29 kcal/kg FFM (10)(28)
- BP <90/60mmHg + EKG looking for bradycardia out of proportion (28)
- BMI <17.5 kg/m2, weight (<85% expected body weight or 10% weight loss/ month),
- Tanner staging,
- Bone stress injury history. (28)

Laboratory parameters

- Vit D: adequate >90 nmol/L) (22)
- Iron profile bianually as screening and quarterly in at risk individuals Ferritin >25 µ g/L Hb >115g/L Transferrin >16% (28)
- Fasting blood glucose < 4 mmol/L
- Endocrine function (luteinizing hormone, follicle-stimulating hormone, and estradiol) according to the phase of the cycle: T3 < 3.5 pmol/L LDL > 3.0 mmol/L, fasting insulin < 20 pmol/L

Addressing the problem

- Identify the primary source of the LEA [14]

A) Unintentional low intake or eating disorder

B) Intentional weight loss with / without eating disorder

- Nutritional Sports nutritionist will asses each athlete to fit their needs [3][13] [14][40][41]

- Reestablish basal energy needs
- Vitamin D, iron, zinc and Vit K, calcium
- BMI >18 kg/m2 or 90% of expected body weight
- Caloric intake 2,000kcal/day, 20-30% surplus 45 kcal/kg FFM
- Protein intake 1.6-2.4g/kg/day [3]
- 25-hydroxy vitamin D levels >30 ng/mL. Supplementation with 600–800 IU [13] [22]
- Calcium: Daily intake 1000 mg/day for men and women 19–50 years, and 1300 mg/ day for children and adolescents aged 9–18 years [13]After training prioritize high calcium meal such as milk based drinks to try to diminish bone resorption post-training. [40]

- DXA scan

LEA or history of stress fracture <6 months) normal > − 1.0 g/cm2 [40][10] [28]

- Cognitive behavioral therapy[13]

If the energy availability does not improve, athletic activity must be suspended and asses if retiring the athlete from the competitive environment is needed [13]

- Skeletal loading exercises

Higher impact protocols increase cortical thickness, higher BMD at hip and lumbar spine in low impact athletes [40][49][30]

Progressive 9 months countermovement jumping program[30]

Countermovement jump

- 3 months: 20 jumps with bodyweight 3/ day 3/ week
- 3 months: 20 jumps with 2kg extra 4/ day 3/ week
- 3 months: 20 jumps with 5kg extra 4/ day 4/ week

PHARMACOLOGICAL TREATMENT

- 1 year non-pharmacological
- Hormonal therapy → no clear benefit a lot of information missing in this population.(14) (51)
- Consider with osteoporosis in DXA scan (14) * FDA has not approved the use of bisphosphonates or denosumab in athletes.
- Consider if Z score < -2 + stress fracture (14)

Hormonal therapy

- No clear benefit
- Oral contraceptives don't increase BMD or reduce risk of stress (3)
- Gynecologist could evaluate estradiol and cyclical progesterone in patients 16-21 years old to support BMD peak and also in patients with anorexia nervosa Recombinant parathyroid hormone is being studied for athletes with very low BMD + delayed fracture healing (closed physis) (14)(51)

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