Relative Energy Deficiency in Male Athletes

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Dr John Sutton 1941-1996

Physician, Researcher, Wilderness Explorer/ Athlete, Family Man and Friend
Dr. John R. Sutton

- Sport Medicine Physician from Australia
- Dean of Medicine, McMaster University
- President, ACSM
- Researcher - effect of hypoxia on skeletal muscle eg in mountain climbers
- Adventurer and pioneer
RED-S
Relative Energy Deficiency in Sport in Male Athletes
RED-S

- Relative Energy Deficiency in Sport is a syndrome of:

  - “impaired physiological function including, but not limited to, metabolic rate, menstrual function, bone health, immunity, protein synthesis, cardiovascular health caused by relative energy deficiency. “

RED-S

- Relative Energy Deficiency
  - Abnormal (reduced) Energy Availability (EA)
  - \( EA = EI - EE \) (sport)
  - RED occurs when the balance between dietary Energy Intake is LESS THAN the Energy Expenditure required for sport activities AND health, ADLs, growth
Energy Availability (EA)

EA is the daily energy available after exercise for expenditure on

- Organ/ cell maintenance & recovery
- Thermoregulation
- Immune function
- Growth
- Reproduction
Reduced EA in RED-S

- Reduced EA can result from:
  - Inadvertent or intentional decrease in EI
  - Increased exercise EE
  - A combination of both
Effects of RED-S

- Abnormal reproductive hormone levels
- Abnormal bone metabolism
- Nutritional deficits
- Reduced immune function
- Impaired training response
- Delay in injury recovery
Health Consequences of Relative Energy Deficiency in Sport (RED-S) (*Psychological consequences can either precede RED-S or be the result of RED-S).
FEMALE ATHLETE TRIAD

- TRIAD of
  - Decreased Energy Availability
  - Menstrual Irregularities (disruption of the HPG axis)
  - Bone metabolism abnormalities
Female Athlete Triad
Disordered Eating in Athletes

- Disordered eating has been reported in:
  - Jockeys
  - Rowers (57% of males)
  - Weight class athletes (up to 70% pre-competition)
  - Runner; Cyclists; Swimmers/ Divers
  - Aesthetic sports
RED-S and Nutritional Deficits

- Inadequate macro and micro nutrients
  - Anemias
- Impaired muscle protein synthesis
- Altered substrate utilization in low CHO state
- Low Vit D, calcium contributing to sub-optimal bone health
## RED-S and Immune Function

Hagmar et al, 2008

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Leanness Disciplines</th>
<th>Nonleanness Disciplines</th>
<th>Statistical Significance (P Value)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Exercise time* (h)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>All</td>
<td>921 ± 353</td>
<td>695 ± 294</td>
<td>0.0001</td>
</tr>
<tr>
<td>Females</td>
<td>982 ± 424</td>
<td>765 ± 328</td>
<td>0.01</td>
</tr>
<tr>
<td>Males</td>
<td>889 ± 309</td>
<td>623 ± 238</td>
<td>0.0003</td>
</tr>
<tr>
<td>Exercise load &gt;10† (%)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>All</td>
<td>59.4</td>
<td>43.5</td>
<td>0.03</td>
</tr>
<tr>
<td>Females</td>
<td>54.6</td>
<td>49.2</td>
<td>0.43</td>
</tr>
<tr>
<td>Males</td>
<td>61.9</td>
<td>38.4</td>
<td>0.01</td>
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<tr>
<td>Illness‡ (%)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>All</td>
<td>38.5</td>
<td>21.6</td>
<td>0.009</td>
</tr>
<tr>
<td>Females</td>
<td>31.8</td>
<td>21.7</td>
<td>0.25</td>
</tr>
<tr>
<td>Males</td>
<td>41.9</td>
<td>21.5</td>
<td>0.02</td>
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<tr>
<td>Injuries‡ (%)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>All</td>
<td>4.6</td>
<td>12.8</td>
<td>0.05</td>
</tr>
<tr>
<td>Females</td>
<td>9.1</td>
<td>13.0</td>
<td>0.47</td>
</tr>
<tr>
<td>Males</td>
<td>2.3</td>
<td>12.7</td>
<td>0.05</td>
</tr>
</tbody>
</table>

*Exercise time during the 12-month period preceding the Olympic games.
†Reporting a subjective, average exercise load of >10 (heavy) for the previous 12 months.
‡Suffering an illness or injury during the 3-month period preceding the Olympic games.
REDS-s and Performance

- High school athletes with DE have increased injury risk:
  - 8X higher in aesthetic sports; 2x higher in other sports
- Low EA in female athletes has been found to decrease:
  - Endurance
  - Speed
- Low EA in male athletes has been found to decrease:
  - Muscle mass accrual
  - Limb strength acquisition
### Table 2. Studies assessing the effect of eating disorders features on sport performance.

<table>
<thead>
<tr>
<th>Eating disorder feature</th>
<th>Studies (n)</th>
<th>First Author and Year</th>
<th>Results</th>
</tr>
</thead>
<tbody>
<tr>
<td>Underweight</td>
<td>5</td>
<td>Boileau et al. [34]</td>
<td>Conflicting and inconclusive results. Early studies reported that leaner individuals perform better, but this finding has not been confirmed in subsequent studies.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Cureton et al. [35]</td>
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<td></td>
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<td>Clark et al. [36]</td>
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<td></td>
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<td>Sherman et al. [37]</td>
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<td></td>
<td></td>
<td>Bonogofski et al. [38]</td>
<td></td>
</tr>
<tr>
<td>Excessive and purging exercising</td>
<td>2</td>
<td>Ragalin et al. [39]</td>
<td>Overtraining is frequent in athletes and may negatively influence sport performance.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Armstrong et al. [40]</td>
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<tr>
<td></td>
<td></td>
<td>Ingjer et al. [41]</td>
<td></td>
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<tr>
<td>Excessive dietary restriction</td>
<td>3</td>
<td>Johnson et al. [42]</td>
<td>Transitory improvement of sport performance due to early starvation effect, with increased cortisol, adrenaline, noradrenaline, and VO₂.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Fogelholm et al. [43]</td>
<td></td>
</tr>
<tr>
<td>Excessive dietary restriction</td>
<td>1</td>
<td>Beals et al. [44]</td>
<td>Deterioration of sport performance due to glycogen depletion, increase in circulatory lactate, dehydration and loss of lean mass.</td>
</tr>
<tr>
<td>Binge eating</td>
<td>1</td>
<td>Rankin et al. [45]</td>
<td>Inconclusive results, but binge eating seems to negatively influence sport performance if associated with excessive weight gain.</td>
</tr>
<tr>
<td>Purging</td>
<td>3</td>
<td>Eichner et al. [46]</td>
<td>Negative effect on sport performance through negative caloric balance, dehydration and hypokalaemia.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Otis et al. [47]</td>
<td></td>
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<td></td>
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<td>Thompson et al. [48]</td>
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</tr>
</tbody>
</table>
RED- S in Male Athletes
RED-S in Male Athletes

- Gravitational and Endurance Athletes report lower EI than predicted for EE
  - Lower BM, FFM and higher DE/ED’s than other sports
- High intensity training and long distance cycling is associated with decreased Testosterone; lower sperm count, abnormal sperm motility
- Endurance and weight sensitive sports exhibit lower BMD
RED-S in Male Athletes

- **Low BMI/ FFM**
  - Cyclists; Runner; Ski Jumpers; Jockeys
  - Periodically: Wrestlers; Martial Arts athletes

- **ED/DE**
  - Cyclists; Runners; Jockeys; Rowers; Wrestlers; Bodybuilders

- **Low BMD**: Cyclists; Runners

- **Low/Altered HPG Axis**: Cyclists; Runners
Low EA in Athletes

- For female and male athletes there may be a syndrome of inter-related dysfunctions of
  - Energy Availability
  - Bone Health
  - HPG Axis
Stress Fractures in Runners

- Reported risk factors vary between female/male subjects.
- Menstrual status and weight is usually reported about female runners with stress.
- Alignment, stride mechanics, weight and hip muscle strength are assessed in male runners.
RED-S in Male Athletes
Management of RED-S

- Knowledge of high risk sports
- (Pre-season) screening
- Awareness of in-season symptoms and signs
- Conduct risk assessment to guide RTP recommendations
RED-S: at Risk Sports

- Endurance sports: running, cycling; Xcountry skiing; triathlons
- Gravitational sports: ski jumping; jumping events (Athletics)
- Weight Class sports: wrestling; martial arts; weight lifting; rowing
- Aesthetic/ judged sports: gymnastics; skating; diving
RED-S: Screening

- PE with comprehensive history and targeted exam
  - Assess for low EA and hypogonadal state; R/O ED and dec. BMD

- Relevant investigations
  - Bloodwork +/- BMD

- Risk Factor Identification and Stratification
  - Sport and sport season modifiers
  - Severity of low EA and consequences e.g. stress #'s
What is the RED-S CAT?

The RED-S CAT is a clinical assessment tool for the evaluation of athletes/active individuals suspected of having relative energy deficiency and for guiding return to play decisions. The RED-S CAT is designed for use by a medical professional in the clinical evaluation and management of athletes with this syndrome. The RED-S CAT is based on the IOC Consensus Statement on RED-S, 2014.¹

This tool may be freely copied in its current form for use by sport organizations and the athlete medical team, and Minor alterations to the tool or reproduction for publication purposes require permission from the International Olympic Committee.

NOTE: The diagnosis of RED-S is a medical diagnosis to be made by a trained health care professional. Clinical management and return to play decisions for athletes with RED-S should occur under the guidance of an experienced sports medicine team.

What is Relative Energy Deficiency in Sport?

The syndrome of RED-S refers to impaired physiological functioning caused by relative energy deficiency, and includes but is not limited to impairments of metabolic rate, menstrual function, bone health, immunity, protein synthesis, and cardiovascular health.

The cause of RED-S is the scenario referred to as "low energy availability", where 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.

The potential health consequences of RED-S are depicted in the RED-S conceptual model (Figure 1). Psychological problems can be both the result of and the cause of RED-S.

RED-S may also affect athlete sport performance. The potential effects of RED-S on sport performance are illustrated in Figure 2:

Screening for RED-S

The screening and diagnosis of RED-S is challenging, as symptomatology can be subtle. A special focus on the athlete at risk is needed. Although any athlete can suffer from RED-S, those at particular risk are those in judged sports with an emphasis on the aesthetic or appearance, weight category sports, and endurance sports. Early detection is of importance to maintain and improve performance and prevent long-term health consequences.

Screening for RED-S can be undertaken as part of an annual Periodic Health Examination and when an athlete presents with Disordered Eating (DE)/Eating Disorders (ED), weight loss, lack of normal growth and development, endocrine dysfunction, recurrent injuries and illnesses, decreased performance/performance variability or mood changes.

doi:10.1136/bjsports-2015-094873
<table>
<thead>
<tr>
<th>STEPS</th>
<th>RISK MODIFIERS</th>
<th>CRITERIA</th>
<th>RED-S SPECIFIC CRITERIA</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>STEP 1</strong> Evaluation of Health Status</td>
<td>MEDICAL FACTORS</td>
<td>- Patient Demographics - Symptoms - Medical History - Signs - Diagnostic Tests - Psychological Health - Potential Seriousness</td>
<td>- Age, sex - See Yellow Light column in RED-S Risk assessment model - Recurrent dieting, menstrual health, bone health - Weight loss/fluctuations, weakness - Hormones, electrolytes, electrocardiogram, DXA - Depression, anxiety, disordered eating/eating disorder - Abnormal hormonal and metabolic function - Cardiac arrhythmia - Stress fracture</td>
</tr>
<tr>
<td><strong>STEP 2</strong> Evaluation of Participation Risk</td>
<td>SPORT RISK MODIFIERS</td>
<td>- Type of Sport - Position Played - Competitive Level</td>
<td>- Weight sensitive, leanness sport - Individual vs. team sport - Elite vs. recreational</td>
</tr>
<tr>
<td><strong>STEP 3</strong> Decision Modification</td>
<td>DECISION MODIFIERS</td>
<td>- Timing and Season - Pressure from Athlete - External Pressure - Conflict of Interest - Fear of Litigation</td>
<td>- In/out of season, travel, environmental factors - Mental readiness to compete - Coach, team owner, athlete family, sponsors support - If restricted from competition</td>
</tr>
<tr>
<td>High risk: no start red light</td>
<td>Moderate risk: caution yellow light</td>
<td>Low risk: green light</td>
<td></td>
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<td>-------------------------------</td>
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<tr>
<td>Anorexia nervosa and other serious eating disorders</td>
<td>Prolonged abnormally low % body fat measured by DXA or anthropometry using The International Society for the Advancement of Kinanthropometry ISAK or non-ISAK approaches</td>
<td>Healthy eating habits with appropriate energy availability</td>
<td></td>
</tr>
<tr>
<td>Other serious medical (psychological and physiological) conditions related to low energy availability</td>
<td>Substantial weight loss (5–10% body mass in 1 month)</td>
<td>Normal hormonal and metabolic function</td>
<td></td>
</tr>
<tr>
<td>Extreme weight loss techniques leading to dehydration induced haemodynamic instability and other life-threatening conditions</td>
<td>Attenuation of expected growth and development in adolescent athlete</td>
<td>Healthy BMD as expected for sport, age and ethnicity</td>
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<td></td>
<td>Abnormal menstrual cycle: FHA amenorrhoea &gt;6 months</td>
<td>Healthy musculoskeletal system</td>
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<td></td>
<td>Menarche &gt;16 years</td>
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<td></td>
<td>Abnormal hormonal profile in men</td>
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<td></td>
<td>Reduced BMD (either from last measurement or Z-score &lt; −1 SD).</td>
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<td></td>
<td>History of 1 or more stress fractures associated with hormonal/menstrual dysfunction and/or low EA</td>
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<td></td>
<td>Athletes with physical/psychological complications related to low EA/disordered eating - ECG abnormalities- Laboratory abnormalities</td>
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<tr>
<td></td>
<td>Prolonged relative energy deficiency</td>
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<tr>
<td></td>
<td>Disordered eating behaviour negatively affecting other team members</td>
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<tr>
<td></td>
<td>Lack of progress in treatment and/or non-compliance</td>
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</table>

BMD, bone mineral density; DXA, dual-energy X-ray absorptiometry; EA, energy availability; FHA, functional hypothalamic amenorrhoea; ISAK, International Society for the Advancement of Kinanthropometry
RED-S and RTP

The RED-S **Return to Play Model** outlines the sport activity recommended for each risk category.

<table>
<thead>
<tr>
<th>HIGH RISK RED LIGHT</th>
<th>MODERATE RISK YELLOW LIGHT</th>
<th>LOW RISK GREEN LIGHT</th>
</tr>
</thead>
<tbody>
<tr>
<td>- No competition</td>
<td>- May train as long as he/she is following the treatment plan</td>
<td></td>
</tr>
<tr>
<td>- No training</td>
<td>- May compete once medically cleared under supervision</td>
<td></td>
</tr>
<tr>
<td>- Use of written contract</td>
<td></td>
<td>- Full sport participation</td>
</tr>
</tbody>
</table>
Recommendations from the IOC Consensus Statement

- For Athlete Entourages
- For Sport Organizations
- For Health Professionals
Recommendations for Athlete Entourages

- Education about RED-S
- Promotion of healthy eating
- Performance goals with reduced emphasis on weight, and increased emphasis on healthy nutrition
- Promotion of awareness that good performance does not always mean good health
- Support of appropriate, timely and effective treatment
Recommendations for HCPs

- Establish multi-disciplinary athlete health support teams
- Education of RED-S detection and treatment
- Implementation of the RED-S Risk Assessment Tool and RTP Model
Recommendaions for Sport Orgs

- Preventative educational programmes
- Rule changes/ modifications to address weight – sensitive issues
- Policies for coaches on healthy practice of managing athlete eating behaviour, weight and body composition
Future Directions

- Education and increased awareness of RED-S
- More research about RED-S and related health conditions
  - Other at risk populations eg athletes with disabilities
- Assessment of clinical management tools
THANK YOU

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