Relative Energy Deficiency in Sports (RED-S)

What is RED-S?

RED-S is a condition in which an athlete experiences changes in their health and performance in response to under-fuelling. The term 'RED-S' was developed by the International Olympic Committee in 2014, and is inclusive of all ages, genders and sports - including dance.

What causes RED-S?

Our body needs energy for many functions. These include vital functions which keep us alive (such as breathing and our heartbeat), and non-vital functions that keep us healthy (such as digestion and hormone production). Our body also uses energy for physical activity.

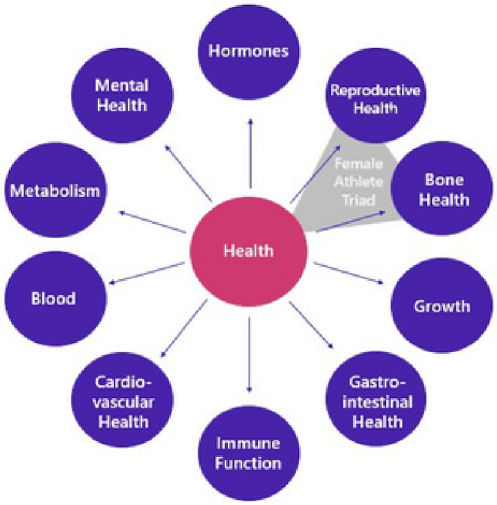
Low energy availability occurs when energy intake from food is not enough to meet our energy needs. You may have also heard this being called an 'energy deficit'. Low energy availability can be caused by not eating enough food, increasing physical activity, or a combination of the two.

When we have low energy availability, our body prioritises vital functions and physical activity to keep us alive and moving. This leaves less energy for our non-vital functions. To help explain why this occurs, think of a phone battery:

Imagine you are at work and need to call a friend at the end of the day to pick you up. However, your phone has only 20% charge. You need to save your battery so you can use your phone for one vital function - making a phone call. To save battery, you stop using your phone's non-vital functions, such as social media or music. While your phone can still make calls, it is not functioning at its full potential.

When an athlete is under-fuelling, their body saves energy by pausing any non-vital functions in a similar way. This can impair both health and sport performance

How Does RED-S Impact Health?



Hormones

Low energy available can suppress the production of many hormones. These include sex hormones needed for reproduction, thyroid hormones needed to control metabolism, hormones which control appetite, hormones required for bone and muscle growth, and hormones that control blood sugar levels.

Reproductive health

Decreased sex hormone production can impact both menstruation and fertility. A common side effect of low energy availability in females is a lack of menstruation, known as Functional Hypothalamic Amenorrhea (FHA). In a female without FHA, a region of the brain called the hypothalamus produces a hormone called Gonadotropin-Releasing Hormone (GnRH). GnRH stimulates a second region in the brain called the pituitary to produce two more hormones, Luteinising Hormone (LH) and Follicle Stimulating Hormone (FSH). An increase in blood levels of LH and FSH stimulates the ovaries to develop a follicle and ovulate. This follicle also releases the hormones oestrogen and progesterone, which thicken the lining of the uterus. This lining is shed during menstruation. However, in FHA the production of GnRH is suppressed, preventing menstruation.

Bone health

The health of our bones is often measured using bone mineral density. Bone mineral density refers to the amount of minerals such as calcium which are stored in bone, giving them strength and rigidity. In RED-S, bone mineral density can be decreased by both low energy availability and decreased production of oestrogen (in females). Oestrogen is important not only for reproduction, but also for maintaining bone mineral density. Due to this, females with RED-S often have a low bone mineral density in their spine, hips and legs, increasing risk of fractures.

Growth and development

Adolescents and young adults with RED-S can experience slower growth and development compared to their peers. This is due to suppressed production of hormones which stimulate bone lengthening and muscle growth. RED-S can also delay puberty.

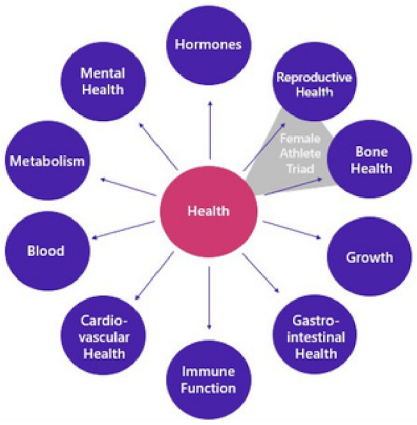
How Does RED-S Impact Health?

Gut health

Low energy availability causes the gastrointestinal tract to slow down. If an athlete is also not eating enough food, having less bulk in the gut can also gastrointestinal motility. This can cause loss of appetite and feelings of overfullness, as food takes longer to move out of the stomach and into the intestine. It can also cause bloating, cramping and wind. This is due to fibre producing gases when it is held in the gut for long periods of time. Athletes may also experience constipation and incontinence, as the gut cannot process and move food through the body at its normal pace.

Immune function

Low energy availability can also suppress our immune system, making us more susceptible to illnesses and increasing recovery times. Risk of respiratory conditions, gastrointestinal illnesses and cold/flu is particularly high, as our body cannot fight off harmful bacteria in our mouth, nose, lungs and gut as well as usual.



Cardiovascular health

Low energy availability causes our body to break down both muscle and fat as an energy source. This can include muscle of the heart and blood vessels, impacting cardiovascular health. Due to this athletes may have a lower heart rate and blood pressure. This can cause fatigue, cold sensitivity, dizziness, or breathlessness. Athletes may also experience a rapid increase in heart rate when exercising, as the cardiovascular system cannot pump blood to our muscles effectively as usual. Long term, RED-S can also increase risk of heart disease. This is due to low oestrogen production in females. Low estrogen levels can increase risk of high blood cholesterol and plaque build-up in arteries, which can contribute to heart disease long term.

Blood

One of the many roles of blood is to carry oxygen around the body, binding oxygen to iron in our blood cells. Iron deficiency is common in RED-S, caused by low intake of iron-rich foods (meat and wholegrains), loss of iron from sweating and tissue damage during exercise, menstruation in females, or a combination of these.

Metabolism

Decreasing the energy used for non-vital functions causes a decline in our resting metabolic rate (RMR). RMR is the amount of energy our body needs to function when we are resting, and does not include energy used for working, concentrating or moving.

Mental health

Low energy availability can impair emotional wellbeing and increase risk of mental health conditions. This can be related to several factors, including decreased production of mood-regulating hormones and not enough energy being supplied to the brain.

How does RED-S impact performance?

Decreased endurance

Our body's primary source of energy is carbohydrate. Under normal conditions, our muscles store a type of carbohydrate called glycogen in muscle, in the same way we fill our tank with petrol. During physical activity, we break down glycogen to provide our body with energy. This is particularly important for long-distance or endurance activity. However, when we have low energy availability, there is less carbohydrate available from food to store in muscle. This can limit endurance performance.

Decreased muscle strength

Low energy availability causes our body to break down muscle for energy. This can result in decreased muscle size and strength, affecting our ability to push, pull, jump and throw.

Impaired judgement, coordination & concentration

Our nervous system (brain, nerves and spinal cord) is responsible for cognitive function and motor control. This requires carbohydrate as an energy source and, unlike other parts of our body, cannot run on energy from muscle or fat. In RED-S, low carbohydrate intake can impair nervous system function. This can affect our ability to make decisions and coordinate movement during performance.

Decreased training response

During exercise, our muscles use up their glycogen stores and sustain micro-damage. After exercise, eating carbohydrate replenishes glycogen stress, and eating protein repairs muscle tissue. This allows our muscles to grow stronger in response to training. When we do not have any spare carbohydrate or protein available to refuel and repair muscle, our body cannot respond to training as usual.

Increased risk of injury

Individuals with RED-S are at increased risk of injury for several reasons. Firstly, impaired concentration and coordination increases the chance of accidents, collisions and falls during sport. Secondly, decreased tissue repair after activity causes our muscles, tendons and ligaments to be weaker and more susceptible to injury during repeated exercise sessions. Lastly, low bone mineral density increases risk of fractures.

Sport at of Risk of RED-S

RED-S can affect individuals from all exercise and sporting backgrounds, including recreational, elite and sub-elite. RED-S is particularly common in sports which place pressure on athletes to lose weight or maintain a low body weight. These can include:

- Gravitational sports: sports in which an athlete must move their body quickly. While it is often thought that a low body weight will improve performance, we now know that this is not true. Common sports include running, cycling and swimming.
- Aesthetic sports: sports which place emphasis on the athletes body shape, often promoting leanness. These include dance, gymnastics and body building.
- Weight category sports: sports in which athletes compete in a specific weight category. These include martial arts, boxing and rowing.

RED-S & Sport Culture

Sporting culture can create barriers to recovering from RED-S. Within some sports, underfuelling and symptoms of RED-S are considered 'normal' or 'all part of being an athlete'. This may cause symptoms to go unnoticed or make it difficult to seek help. Even once RED-S is recognised, this can cause feelings of isolation from peers, coaches and sporting communities during recovery.
However, it is important to remember that RED-S is a serious condition. Sport will always be there to return to, but an athlete only has one body. If you are experiencing difficult emotions during your recovery from RED-S, your dietitian can provide you with support.

Misconceptions About RED-S

"RED-S is the same as the Female Athlete Triad"

The Female Athlete Triad is a model which was previously used to describe how low energy availability affects the health of females. This described the relationship between low energy availability, menstrual dysfunction, and poor bone health. However, we now know that low energy availability affects multiple body systems as well as sport performance, and can occur in athletes of all genders. This led to The Female Athlete Triad being replaced by RED-S.

"RED-S only occurs to people who are underweight"

RED-S is caused by low energy availability, not by body weight. Individuals of any shape or size can experience low energy availability, and therefore can experience RED-S.

"You cannot have RED-S if you are not losing weight"

Our bodies respond to low energy availability in many ways. While some individuals experience weight loss, this does not always occur. Many people experience symptoms of RED-S without losing weight.

"You need to have a large energy deficit for RED-S to occur"

The 'relative' in RED-S explains that each individual will experience symptoms in response to varying degrees of energy deficiency. Some individuals will experience symptoms in response to a smaller energy deficit, while others won't experience symptoms until they are in a larger energy deficit. Regardless, the symptoms are RED-S are equally as serious.

Recovering from RED-S

To recover from RED-S, an individual needs to have enough energy to meet their requirements. This can be accomplished by increasing energy intake from food, decreasing energy expenditure from physical activity, or a combination of both. As each individual experiences RED-S in response to different degrees of low energy availability, the amount of change needed will vary from person to person.

1. Increase energy intake

There are many ways to increase energy intake, and your dietitian can help you find what works best for you.

Some examples include:

- Eat regularly, including 3 meals and 2-3 snacks every 3-4 hours. This provides plenty of opportunities to eat over the day.
- If training for sport, ensure that you have a meal or snack both 2-4 hours before and immediately after exercise to fuel and recover from activity.
- Enjoy foods from all food groups, including meat and dairy.
- Include a source of protein, grains/starch and fat at every meal.
- Decrease portions or servings of high-fibre foods such as fruit and vegetables. These take up room in the gut and suppress appetite, making it more difficult to eat enough energy.
- Use nutritional fluids such as milkshakes and juice if your appetite is low.
- Ensure that your week includes regular 'fun foods' and social meals.
- Your dietitian may also help you build a meal plan.

2. Decrease exercise

If your training is managed by a coach, they can support you to adapt your exercise while recovering from RED-S. If you plan your own training, some of the following strategies can be used to decrease exercise:

- Decrease the frequency, duration, or intensity of your workouts
- If decreasing frequency of workouts, try scheduling another activity when you would usually be exercising. This may help manage any initial, challenging emotions.
- If decreasing duration, try to limit distractions during exercise. Being more mindful of your body sensations may allow you to be more satisfied from lower intensity or shorter duration activity.
- To decrease intensity, try 'swapping' instead of 'swapping'. Find activities which are slower in pace but similar in structure or environment to your usual exercise. For example, swapping jogging for walking.
- Try exercise with a defined duration or intensity. This may relieve the pressure to "push" yourself during activity. Examples include group exercise classes.
- Try new sports, shifting your focus from fitness to skill development.
- Explore social sports with a more relaxed environment.

3. Recover

Like under-fuelling, not allowing sufficient time to recover from exercise can contribute to RED-S. Strategies to ensure you are recovering effectively from training or competition can include:

- Get plenty of sleep every night
- Schedule regular rest days from training and competition
- Avoid food restriction on rest days. Rest days provide an important opportunity to recover from yesterday's activity and fuel for tomorrow.
- Allow plenty of time for injuries to recover prior to returning to exercise.

Further information

If you would like to know more about RED-S, we recommend the following resources:

- Australian Institute of Sport https://www.ais.gov.au/
- International Olympic Committee https://olympics.com/ioc