Appendix 3. Five REDs case-studies and individual physician scoring for validation.

			Josh	Sarah	Emily	Gary	Lucy
		REDs CAT2	**ORANGE**	**RED**	**GREEN**	**RED**	**YELLOW**
Physician Assessment	Physician 1	Norway	Orange	Red	Yellow	Red	Yellow
	Physician 2	Australia	Yellow	Red	Green	Red	Orange
	Physician 3	UK	Orange	Red	Green	Red	Yellow
	Physician 4	UK	Yellow	Orange	Green	Orange	Yellow
	Physician 5	Japan	Orange	Red	Yellow	Orange	Orange
	Physician 6	Canada	Orange	Red	Yellow	Red	Orange
	Physician 7	Sweden	Orange	Red	Yellow	Red	Orange
	Physician 8	Canada	Orange	Red	Yellow	Red	Yellow

Josh

23 years old presents June 2019.

2019 endocrinology presentation being told "your testosterone is low"
Elite diver returned from a university diving scholarship in the US. In 2016 just missed Olympic selection and found this extremely mentally challenging. In 2017 became aware of fatigue and drop in mood and drop in sex drive. Had a big year, 5 big competitions won some gold medals but in retrospect probably "burnt out". He became body conscious describing himself as "on the edge of having an eating concern".

History of previous supplement use but no supplements at the time of hormone testing. He describes "eating in a way that is normal for an athlete – experimenting with intermittent fasting, avoids dairy, gluten and "junk foods". Intermittent fatigue and low mood. No gut symptoms. Intermittent musculoskeletal niggles but no major injuries. Reports sometimes experiencing symptomatic orthostatic intolerance (not always). Training 25 hours per week, coaching 7 hours per week.
No other medical problems, no prescribed medications and is currently taking magnesium, zinc, selenium, L-arginine, Ashwagandha, N-acetylcysteine and Tribulus.

Injury Hx
Bone stress injury to right TA transverse process (March 2014). No other bone stress injuries.

Examination findings: Height: 1.83 m, Weight 68 kg, BMI 23.
Normal CBC/FBC and thyroid tests.
Brain and pituitary MRI scan normal.
Bloods in June 2019 (at time of exam):
Testosterone 10.2 nmol/L (8.7-29)
Cortisol 8am 650 nmol/L (<200)
T4 18 pmol/L (11-22)
TSH 2.7 mIU/L (0.4-4)
IGF 1 144 ng/ml (135-412)
LDL Cholesterol 4.55 mmol/L (1.5-3.0)
Blood pressure 85/55 mmHG
BMD -1.5 at the lumbar spine
All other tests normal including all tests for eating disorders.

Nutrition Review

Significant training load, training 7-8 hours per day (morning and afternoon Mon-Thurs, 5-6 hours diving + 1-2 high intensity resistance training, gymnastic sessions). Sat & Sun – 2-3 hours diving +1-2 hours high intensity circuit-based training. One rest day per week. Recently reintroduced breakfast after experimenting with intermittent fasting. Focuses on his nutrition being "clean", consumes protein with vegetables at main meals, rolled oats with nuts / seeds + water. Minimal to no fueling during trainings, likes to feel "light during training" avoids eating to bigger portions prior to trainings to avoid GI discomfort during diving. Has 3 main meal eating structure with some fruit at times between meals. Very conscious about body composition, looking to continue to reduce body composition in lead up to Olympic qualifying in 6 months.

Sarah

A 18 year old female distance runner presents in the summer of 2020, who only took up running 2.5 years ago, has already qualified for the national team for both the world junior championships (in the 1500m, she placed 6th in the world as a 16 year old, and set the National Junior 1500m record in the process) as well as the World Cross-Country Championships (13th in the world as a 17 year old). Accordingly, she is being fast tracked onto National Teams Talent Development Tracking program. She is coached by a local junior coach who has never coached a talent like this before. Her mother is a former national team gymnast and her father is a local successful businessperson, and she is a straight A student.

In the previously 2 years her weight unexpectedly dropped down 55 kg to 46kg and she is 166cm (BMI = 16.7). The athlete has been working with the team dietitian. No food avoidance. Aiming for Olympic games in Paris 2024. Some difficult social family stress in 2019-2020, now resolving. No gut symptoms, normal energy levels. Mild acne and occasional anxiety. She has had 2 bone stress injuries this year: 2 stress fractures, metatarsal a year ago and now the cuboid (which is what caused her to come in for a full assessment). At 18 she has yet to have her first menstrual cycle, and is not on any type of birth control.

Investigations (summer of 2020)

Testosterone 0.7 nmol/L (0-1.9)

FSH 1.2 IU/L (3-10)
LH 1.5 IU/L (2-9)
Estradiol 163 pmol/L
T4 6.0 pmol/L (9-20)
TSH 1 mIU/L (0.4-4)
Prolactin 55 mIU/L (60-620)
Resting HR = 36
Resting BP =82/45 mmHG

Bone Density 2020: Lumbar spine z score = -2.2, hip = -1.8

Nutrition Review

She loves "clean eating" and is very disciplined around her eating and recently became a vegetarian, which is encouraged by mom and dad as great dedication. Despite this clean eating, she has GI issues, and says they are better when she is gluten and dairy free. She has yet to be assessed for any eating disorders. Has highlighted many instances of urinary incontinence, and episodes of dizziness as well as "passing out" at the finish line of several recent XC races (just before her cuboid injury), where low blood glucose was recorded by the finish line medical crew.

Despite taking 100mg of elemental iron / day as a supplement, her ferritin hovers between 15 to 20 ng/mL

However, her portion size are moderate to low, she has minimal fueling during key training sessions. She recovers post training in the form of isolated protein shakes and has no targeted nutrition approach to significant training days. She runs 120km per week, but then usually also includes 30 to 60min of X-training per day on top of her running (these are levels approached by most elite senior level athletes).

Emily

Hx

25-year-old elite female sprinter of Nigerian decent reports in December of 2021. Referred by a sports dietitian who has been working with the athlete and wants to be sure of the diagnosis. Has increased fueling by 300 calories/day for the last 6 months on the dietitian advice.

Now: avoids dairy and follows low gluten due to GI upset. Training 15-20 hours per week (including weights, physio etc). Previously diagnosed with post glandular fever fatigue from 3 years ago that is ongoing.

Examination: Height: 1.67m Weight: 63 kg BMI 23

Eating Disorder Questionnaire Score – 1.9 (scores >2.3 indicate higher risk for ED's in women)

Menarche age 16 years developed a regular cycle quite quickly and maintained this until age 18 years when menstrual frequency changed to having a regular cycling, except missing 2-3 periods per year (usually during competition phase of the year). Has not been on OCP since age 21.

Bone density 25 years old:
Lumbar spine: z=-0.6
Hip z= +1.4

Injury Hx

Tibial Stress Fracture June 2017
Calf tear March 2017
Significant Achillies tendinopathy (both sides) 2018-2019.

Sometimes has urinary incontinence.

Resting Metabolic Rate (RMR) was performed, indicating 0.89 ratio for measured vs. predicted.

Bloods:
FSH 2.9 IU/L (3-10 lab normal reference range in brackets)

LH: 2.3 IU/L (2-9_
Estradiol 311 pmol/L (50-500)
Prolactin: 197 mIU/L (<600)
Testosterone: 0.7 nmol/L (<1.9)
Cortisol 8am 134 nmol/L (<200)
IGF 1 340 ngm/ml (100-356)

Free T3 4.21 pmol/L (3.55-5.70)

Nutrition Review

Reports history of energy restriction over the past 5 years during competition phase (2 to 3 months/year) to optimize body composition. Still has strong desire to be leaner again for upcoming season, finding it hard for body fat levels to change as she reduces weight for season preparation. Regular eating pattern, very clean eater with lean proteins and vegetables for main meals, limited carbohydrate availability during and after trainings.

Gary

An 18 year old male elite gymnast. The athlete is 5 foot 7 inches and 110 pounds (170cm and 49.9kg; BMI = 17.3; but was 120 pounds 2 months ago). The athlete's mother is a former dancer and has osteoporosis.

The athletes has a life history of 5 stress fractures, however 3 of them were from accidents (bicycle fall, skateboarding 3 years ago and falling during gymnastics practice 1.5 years ago). 1 was a metatarsal stress fracture 5 years ago when the athlete still ran X-country and 1 was a femoral neck stress fracture about 1 year ago. Currently is training full.

Investigations:
Total Testosterone 6.7 nmol/L (8.4-28.8 nmol/L; lab normal reference range in brackets)
Ferritin 22 ug/L (24-444)
Free T3 2.45 pmol/L (2.60-5.80)
DEXA scan z-score of -1.8 at the lumbar spine and -1.6 at the femoral neck
Resting HR = 38 and BP 88/55

Nutrition Review
Reports a history of very "clean" and disciplined eating, and is vegan. Reports low libido/sex drive. He has been anaemic twice in the last 4 years. He trains 15 hours / week. The athlete is ranked #2 in the world, and it is 6 months pre-Olympics. Has scored 2.1 on the EDE-Q (eating disorder questionnaire), which is higher risk for an ED, and has been sent to psychologist to assess whether there is a DSM-5 eating disorder (outcome pending).

Lucy

20 years old at presentation December 2017
Elite Female Road cyclist
Menarche age 16 years. Initially mildly irregular cycles moving to 28-30 days 12 months after menarche. Menstrual cycles remained regular until Lucy travelled to the USA to compete in June of 2017 and no period since then (now Dec 2017).

Training – 6 days per week plus 3 gym sessions per week. Also doing a part time university degree and has two part time jobs (babysitting and waitressing). Many months of the year Lucy is competing outside of the country with very little social support. Only returns home for 3-5 months/year. Recently has had some relationship life stress as well. No past medical history, no prescribed medications but does take fish oil, Vitamin C and beta alanine. Non smoker.

Avoids gluten due to gut upset. Feels the cold. No history of musculoskeletal injury or stress fractures.

Examination findings: Height 1.63m Weight 48 kg Waist circumference 66cm BMI 18.1

No other examination findings of note – specifically no hirsutism or acne, no goiter.

Eating Disorder Questionnaire Score – 1.8 (scores >2.3 indicate higher risk for ED's in women)

Investigations:
Blood pressure 95/62; resting HR 47
Testosterone 1 nmol/L (<1.9; lab normal reference range in brackets)
Cortisol 8-9am 724 nmol/L (<200)
LDL Cholesterol 2.88 mmol/L (1.6-2.8)
FSH 5.4 IU/L (3-10)
LH 1.3 IU/L (2-9)
Estradiol < 50 pmol/L (50-500)
TSH 1.1 mIU/L (0.4-4)
T4 11 pmol/L (10-20)
IGF 1 215 ng/ml (129-499)
Prolactin 99 mIU/L (<600)
Bone Density December 2017 (at presentation):
Lumbar spine z score = -0.5
Hip z score = +0.3
Baseline Intake Review

Initial appointment: General well-balanced approach to nutrition, consumes all food groups, inconsistent in day to day with snacking and energy density of main meals. Moderate to large portion sizes (perhaps a bit light in carbohydrate intake), ad-hoc approach to fueling on the bike. Includes consistent recovery (isolated protein supplement, low in calories and carbohydrate). Trains every morning 1-4 hours on the bike (range of intensities), Gym in afternoon 2x per week, 1x rest day pe week. Exercise Energy expenditure ranges between 750 -1,900 Kcal according to Garmin data.

Follow up appointment – 6months later (overseas, competing).
Reports significant fatigue as race season has begun (tour rider). Constant feeling of fatigue that she can't brush, compounded in heat. Upon nutrition review a likely reduced energy intake compared to initial assessment due to greater time on bike, irregular fueling and recovery strategy post each ride. Limited appetite due to significant fatigue. But, also significant life stress (jobs, relationships).