# Relative Energy Deficiency in Sport (RED-S) in Lightweight Rowing: Investigating Athlete and Physiotherapists' Perspectives

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# Abbreviations

| | |
|---|---|
| AA: | Anorexia Athletica |
| AN: | Anorexia Nervosa |
| BMD: | Bone Mineral Density |
| BMR: | Basal Metabolic Rate |
| DE: | Disordered Eating |
| ED: | Eating Disorder |
| EE: | Energy Expenditure |
| EA: | Energy Availability |
| F.A.T.: | Female Athlete Triad |
| FHMD: | Functional Hypothalamic Menstrual Disorder |
| GI: | Gastrointestinal |
| IOC: | International Olympic Committee |
| LEA: | Low Energy Availability |
| LED: | Low Energy Deficiency |
| LBMD: | Low Bone Mineral Density |
| RED-S: | Relative Energy Deficiency in Sport |
| RED-S CAT: | Relative Energy Deficiency in Sport - Clinical Assessment Tool |
| RMR: | Resting Metabolic Rate |

# Chapter I Abstract


## 1.1 Objective

There is a high prevalence of Relative Energy Deficiency in Sport (RED-S) in weight-dependent athletes, potentially resulting in long-term health implications if not managed and treated correctly by healthcare professionals. The aim of this research is to i) investigate the physical and psychosocial impact of RED-S, from the personal perspective of lightweight rowers in the UK and ii) investigate the knowledge and management of RED-S in lightweight rowers and physiotherapists working in lightweight rowing.

## 1.2 Methods

Twelve lightweight rowers and twelve physiotherapists were recruited for the semi-structured interviews. Eligibility criteria for lightweight rowers were: aged ≥18 years, had competed in lightweight rowing for ≥1 year, and experienced ≥1 symptom of RED-S (recurrent injuries including stress fractures, menstrual dysfunction, low energy during training, prioritising leanness, excessive fatigue, muscle loss, an inability to recover from sessions, a diagnosis of RED-S or Female Athlete Triad. To be eligible, physiotherapists had to be currently or previously registered to work in the UK and have worked with lightweight rowers for ≥1 year. All participants undertook audio-recorded semi-structured telephone interviews. Data was analysed using an inductive thematic approach, and coding was iterative and data-driven, facilitated by NVivo software.

## 1.3 Results

To address the first aim, twelve current and former lightweight rowers (67% female, 33% male, aged 19-32 years), who competed in lightweight rowing at an international level to elite level were interviewed. Participants restricted calories and increased energy

expenditure to elicit weight-loss in order to pass weighing-in and compete as a lightweight rower. This resulted in psychosocial implications (reduced social interaction, difficulty maintaining relationships, poor emotional regulation, low mood, poor concentration, disordered eating, guilt and anxiety around food and a negative body image) many of which persisted after ceasing participation in lightweight rowing. Participants described a range of physical implications, including disrupted sleep, decreased performance and recovery, bowel disruption, menstrual dysfunction, fatigue, musculoskeletal pain, injury and weakened immune systems.

To address the second aim, data from 12 lightweight rowers and 12 physiotherapists (50% male, and 50% female, aged 22-64 years, with 1-20 years of experience working in lightweight rowing) were utilised in this study. Five key themes were identified: insufficient knowledge of RED-S, inadequate RED-S education, inappropriate management of RED-S, referring responsibility to other health professionals, and prioritising performance over health. Participants provided suggestions for improving knowledge and management of RED-S in lightweight rowers, including formal physiotherapy education and training, and targeted education for athletes and coaches.

## 1.4 Conclusion

This study describes short and long term physical and psychosocial impacts of RED-S, from the personal perspective of lightweight rowers. This highlights the importance of screening, education and effective management strategies from healthcare professionals to reduce the negative health implications of RED-S in lightweight rowers. There was a significant lack of awareness of RED-S amongst physiotherapists and lightweight rowers. Most physiotherapists were not confident discussing or managing RED-S in athletes, and

lightweight rowers were dissatisfied with the management they received. Improving RED-S education for physiotherapists may have significant and positive health implications for lightweight rowers in the UK.

# Chapter II Background

## 2.1 Introduction

Relative Energy Deficiency in Sport (RED-S) is a revised model of the Female Athlete Triad (F.A.T.), established by the International Olympic Committee (IOC) in 2014 (Mountjoy et al., 2018). Unlike F.A.T., RED-S recognises that male and female athletes can suffer from the effects of low energy availability (LEA). RED-S expands upon F.A.T., which only consists of three symptoms in female athletes: menstrual dysfunction with or without amenorrhea, low bone mineral density (LBMD) with or without osteoporosis, and LEA with or without an eating disorder (ED). RED-S incorporates a multi-dimension of symptoms which can affect males, females, athletes and non-athletes. The symptoms of RED-S include under-recovery, overtraining, increased injury, reduced athletic performance, reduced glycogen stores, poor muscle strength, an increase in anxiety and depression, reduced coordination, impaired judgement and concentration in and out of sport (Mountjoy et al., 2018). The implications of RED-S affects “menstrual function, bone health, the endocrine system, metabolic system, haematological system, growth and development, cardiovascular system, gastrointestinal system, immunology and psychosocially” (Mountjoy et al., 2018).

The Female Athlete Triad (F.A.T.) was first identified as a syndrome in 1993 by the American College of Sports Medicine. However, there have been associations between low bone mineral density, stress fractures, eating disorders and female athletics for decades before the syndrome was formally named (Gottschlich et al., 2017). Current literature predominantly focuses on F.A.T. due to RED-S being a relatively new concept, and there has been no published research looking at the psychosocial implications the symptoms of RED-S have on the high-risk category of lightweight rowers. Lightweight rowers have to meet weight requirements two hours before competing. For men, summer international

weight is 70kg, and 57kg for women. The dieting process and strict weight regime will be discussed within this thesis highlighting why this group of athletes are at a high risk of RED-S. There is limited published research on lightweight rowers; therefore, this thesis research will aim to close this gap in the literature. However, the literature on F.A.T. can be used to inform RED-S research and management. Although RED-S has been described as a 'global epidemic' (Health24, 2019), the exact overall prevalence of RED-S in the UK is largely unknown. Additionally, many athletes are unaware of the symptoms of RED-S, and consequently, the condition often goes undiagnosed. Relative Energy Deficiency in Sport remains poorly recognised by health care professionals (HCP) and coaches (Mountjoy et al., 2018). Within elite weight classification sports, it is estimated that 70% of athletes suffer from ≥1 symptom of RED-S (Vanbaack et al., 2016). Infographics of RED-S have recently been created (Keay et al., 2019), which aim to increase awareness among healthcare professionals. Although this information is available, no study has looked at the physiotherapists' knowledge of RED-S or how they manage the condition.

## 2.2 RED-S

### 2.2.1 Epidemiology and development of RED-S

The Female Athlete Triad (F.A.T) was first established in 1992 and recognised as an association of amenorrhea, disordered eating (DE) and osteoporosis for female athletes in sports which emphasise leanness or are weight dependent. Over the past 28 years, science and research have evolved, and so has the term F.A.T., now known as RED-S (Gottschlich et al., 2017). RED-S is a multi-dimensional syndrome which causes impaired physiological function, which can impact upon immunology, menstrual function, bone health, the endocrine system, metabolic rate, haematological system, growth and development, psychological function, cardiovascular and the gastrointestinal system (Mountjoy et al.,

2014). The IOC describe the syndrome of RED-S as referring 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.” (Mountjoy et al., 2014).

Almost all research conducted on F.A.T. up until 2014 has focused on female athletes. However, after the revision of F.A.T. to RED-S in 2014 by the IOC, the statement declared the symptoms of the triad are no longer confined to female athletes, as male athletes can also be affected (Mountjoy et al., 2014). Protecting athlete health is an imperative goal for the IOC, who published a Consensus Statement in 2014 based on the current scientific evidence on F.A.T. and updating it to be relevant to RED-S (Mountjoy et al., 2014). F.A.T. is considered to cover a spectrum of disorders: the severity of an athlete’s condition varies along the spectrum depending upon their diet and exercise (VanBaak et al., 2016).

The underlying problem of both F.A.T. and RED-S is an inadequacy of energy to support bodily functions required to maintain optimal health. The energy availability an athlete has is calculated as energy intake minus the cost of energy used during exercise. Whilst the exact prevalence of RED-S is yet to be identified; the available literature provides some statistics on the prevalence of some of the signs and symptoms of RED-S. A comprehensive narrative review by Joy et al. (2016), identified a 20% higher prevalence of disordered eating (a symptom of RED-S) in both male and female athletes compared with non-athletes.

## 2.3 Symptoms of RED-S

### 2.3.1 Low Energy Availability (LEA) (with or without an eating disorder)

The primary indicator that an athlete is suffering from RED-S is LEA, which occurs when the body lacks enough energy to maintain physiological functions to achieve optimal health and performance. Athletes who have weight restrictions or have an emphasis on leanness are at a significantly higher risk of LEA compared to non-athletes and non- weight dependent or leanness athletes, due to the extreme weight restrictions of their sports (Mountjoy et al., 2014). An athlete's energy availability (EA) is measured as dietary intake minus energy expenditure (EE) in units of Kcal/kg free-fat-mass/day (De Souza et al., 2019). Eating disorders association with RED-S is a continuum from optimal EA to LEA with or without an eating disorder (ED) (Nattiv et al., 2007).

Athletes suffering from LEA may be inadvertently under-eating relative to their energy expenditure, or athletes may be purposefully under-eating to reach a specific sport-related weight classification (Manore., 2015). Examples of weight-restricted sports are boxing and lightweight rowing. Aesthetically lean athletes compete in sports where it is seen as beneficial to be lean for speed or performance including long-distance running and gymnastics. Athletes within such sports may not have a 'significant psychopathology' of DE, therefore, do not fulfil the criteria for a clinical ED as defined by the Diagnostic and Statistical Manual of Mental Disorders (Diagnostic and Statistical Manual of Mental Disorders, 2014). Consequently, such athletes may not receive appropriate treatment for their DE habits because their eating habits are associated with sport rather than altered psychology (Sundgot-Borgen et al., 2004). Disordered eating and ED due to LEA are more prevalent amongst female and male athletes competing in weight-dependent sports in comparison to

female and male athletes who compete in sports which are not weight sensitive (Mountjoy et al., 2018).

Loucks (2003) highlighted that DE includes a spectrum of behaviours ranging from failure to intake the correct number of calories, to extreme measure weight-loss strategies, such as laxative consumption, a practice which is not uncommon in many athletes (Werner et al., 2013). An athlete who develops an ED such as anorexia nervosa (AN) (also known as anorexia athletica (AA)), has an increased risk of sudden death (Franko et al., 2013). A longitudinal investigation into mortality rates of anorexic patients from 1987, (n=264 females) found that at 20-23 years follow up 16, deaths had occurred in individuals who had anorexia or bulimia. This study concluded the risk of premature death amongst individuals with AN peaked in the first ten years. Whilst this study looked at the general population who had anorexia, the results and conclusions can be applied to athletes in weight-dependent sports as they are also at risk of premature death if they suffer from AN in pursuit of their sport (Franko et al., 2013). Premature deaths could be prevented if the support networks around the athlete were aware of the signs and symptoms of DE. Research by Thiemann et al., (2015) suggests athletes under pressure to conform to weight classifications have a 57.3% chance of having an ED, compared to 3% of athletes in ball game sports with no weight classification, highlighting the importance of appropriate education of this high-risk athlete group.

Sundgot-Borgen et al., (2004) studied the prevalence of AN, AA, bulimia and other EDs in 1620 elite female athletes and compared the results to 1696 members of the general Norwegian population. This study included a questionnaire followed by a clinical interview. The results found 13.5% of elite athletes had an ED, compared to 4.6% of the general

population. Additionally, elite athletes in leanness aesthetic or weight-dependent sports were more likely to suffer from an ED (42%), compared to athletes in endurance sports (24%), athletes in technical sports (17%) and athletes in ball sports (16%). Thus, the prevalence of ED is higher amongst elite leanness and weight-dependent aesthetic sport athletes (sports that perceive being lean and thin as beneficial) compared to other sports as well as the general population. The authors suggested a collaborative approach to be adopted amongst "coaches, athletic trainers, parents, physicians, and athletes" to help recognise, prevent and treat ED amongst athletes' (Sundgot-Borgen et al., 2004). Although this study was conducted in Norway, the results may apply to the U.K athletes participating in weight classification sports.

### 2.3.2 Low bone mineral density (with or without osteoporosis)

A symptom of RED-S is low bone mineral density (LBMD), measured through skeletal bone health (Mountjoy et al., 2014). Bone mineral density (BMD) is a measure of bone strength represented by the calcium content (Ackerman et al., 2011). Low bone mineral density increases the likelihood of osteoporosis, accounting for 40% of osteoporotic patients (Facts and Statistics, 2019). Ackerman et al., (2011) identified the overall calorific consumption as vital to maintain appropriate energy balance as well as optimising bone health and the skeletal development system. Damage to the skeletal system can be exacerbated in athletes with a high EE as well as a low calorific input (Ackerman et a., 2011).

If LBMD is left untreated, an athlete is at risk of developing osteoporosis, which is commonly diagnosed as a result of post-stress fracture resulting in further investigation. Therefore, HCPs must monitor athlete injuries and general health, ensuring early warning signs of LBMD are detected so that other investigations can take place. Osteoporosis is a medical

condition defined by bone density comprising of reduced bone formation and excessive bone loss, causing an imbalance and increasing fracture risk (Sozen et al., 2016). The first stage of osteoporosis is known as osteopenia (a reduction of proteins and minerals inside bone tissue) (Bouillon., 2010). Health care professionals should be aware of this so they can monitor athlete's (especially those who are weight restricted) mineral intake for optimal bone health. Lundy et al., (2015), assessed (n=125) international rowers who competed between 2011- 2014, using a DEXA scan. The results found 5.6% had LBMD in their spine, 1.6% had LMBD in their femur, and the worse affected athletes were the lightweight rowers, compared to the heavyweight rowers (Lundy et al., 2015). This study shows the clinical benefits of using a DEXA scan on athletes to facilitate diagnosis and appropriate treatment. This study highlights rowers, specifically lightweight rowers, are at high risk of developing LBMD, potentially resulting in osteoporosis.

Nazem et al., (2012) reported the most significant accretion of bone mass occurs during puberty around 14 years old and continues to approximately 21 years of age. Adolescent athletes participating in high-level sport and weight restricted sport may delay the onset of menarche. Combining this with low-calorie input may result in maximal bone mass, meaning they will never reach their full accretion potential. Increasing the vulnerability of the athlete throughout their life (Nazem et al., 2012). Ninety-two percent of bone mass is achieved by 18 years; reducing bone deposition in early adulthood can increase the severity of bone loss with ageing and menopause (Nazem et al., 2012).

Siris et al., (2002) highlighted BMD as the single best predictor of fracture risk in asymptomatic postmenopausal women. A longitudinal study was conducted between 1997-1999, in 200 50-year-old women with no previous osteoporosis diagnosis. The results found

39.6% had osteopenia, and 7.2% had osteoporosis. Almost half the sample population had undetected LBMD including 7.2% with osteoporosis. Whilst the study sample was not athletes, this study highlights that at-risk individuals may be asymptomatic and unaware of their osteoporosis or LBMD status (Siris et al., 2002).

Ducher et al., (2010) reported adolescent athletes might only become aware of BMD if they have reoccurring stress fractures resulting in formal bone health investigations. Barrack et al., (2013) found that once athletes reduce their calcium and vitamin D intake, malnutrition can cause necrosis of the bone post stress fracture. Postmenopause BMD decreases naturally and can result in osteoporosis; however, the severity could be increased if a woman is malnourished as an adolescent. Whilst most of the current literature focuses on the effect LBMD has on the female body, since RED-S has been identified to allow the inclusion of males, more studies are starting to take place on the impact BMD has on males.

Keay et al., (2018), used a mixed-method to investigate 50 competitive male road cyclists. Each participant received a DEXA scan, blood test, a sport-specific questionnaire and a clinical interview. This study observed 28% of the male cyclists had LEA and low lumbar spine LBMD was identified in 44% of the cyclists. Ten cyclists had chronic LEA and had lower levels of testosterone compared to participants with adequate EA. The mean Vitamin D level was below the recommended level for athletes (90nmol/L). Keay et al., (2018) emphasises the importance of raising awareness for male athletes in high-risk sports.

The International Osteoporosis Foundation estimates at least 40% of females and 15-30% of males suffer one or more fragility fractures secondary to osteoporosis (IOF, 2019). There is considerable economic burden attributed to this; the cost of fragility fractures on the UK

economy was estimated at £1.8 billion in 2000, which is predicted to rise to £2.2. billion by the year 2025 (NICE, 2019). The National Institute for Health and Care Excellence (NICE) guidelines report osteoporosis causes around 9 million fractures worldwide per year, 300,000 of which are in the UK (NICE, 2019). This number will continue to rise if young athletes are damaging their bone health (NICE, 2019). Therefore, action must be taken to ensure LBMD is detected and managed early in athletes.

### 2.3.3 Hormone imbalance and menstrual dysfunction (with or without amenorrhea)

A key indicator of female hormone imbalance is menstrual dysfunction (Keay., 2018). Whilst men don't menstruate; they can suffer hormone imbalance symptoms including fatigue, insomnia, weight gain, depression and an inability to maintain muscle mass (Decaroli et al., 2016). The endocrine system comprises hormones and glands to coordinate natural bodily functions working closely with the nervous system. Hormones are chemical messengers secreted into the bloodstream, which is a transportation method to organs and tissues. There are 50 different hormones within the body (Kloss et al., 2018), a wide variety of which are produced by the endocrine cells most of which are within the glands. The hormones act as an internal chemical communication system controlling and coordinating activities within the different targets of the body (Kloss et al., 2018).

Whilst physical activity is beneficial for health by decreasing cardiovascular disease, reducing the risk of cancer and type 2 diabetes, female athletes participating in high-intensity physical activity, have increased risk of menstrual dysfunction which can subsequently lead to infertility (Aherns et al., 2014). Therefore, it is vital menstrual cycles of female athletes are monitored. Females with RED-S can suffer menstrual dysfunction with or without amenorrhea. There are two types of amenorrhea; primary amenorrhea occurs at

15 years of age, in girls who have not yet experienced a period (menarche). Secondary amenorrhea is the absence of a menstrual cycle for three months or more after menarche (Nawaz et al., 2019). Birch (2005) explained that female athletes could have menstrual dysfunction without amenorrhoea as irregular periods constitute a dysfunctional menstrual cycle. The cause of menstrual dysfunction is attributed to low levels of oestrogen and progesterone, adversely affecting follicular development, potentially causing an absence of ovulation (Aherns et al., 2014).

Complicating this picture further, RED-S may affect the onset of menarche. Torstviet et al's. (2005) studied n=669 current or former elite female athletes aged 13-39 years from lean sports and n=607 non- leanness athlete controls of the same age group. The types of sports were not stated, making it impossible to compare sports. Participants completed questionnaires assessing menstrual history, oral contraceptive use, ED inventory and weight history. The study found intense sport-specific training from adolescent age can delay menarche, particularly for leanness/aesthetic meaning their sport is either weight controlled in order to participate, or there is an emphasis on being thin as a benefit to the sport (such as gymnastics). Suggesting that, weight dependent or aesthetic athletes have an increased risk of developing RED-S compared to non -leanness sports, where being lean is not seen as beneficial (Torstviet et al., 2005).

### 2.3.4 Metabolic rate

Low energy availability is associated with a decreased resting metabolic rate (RMR) in endurance athletes (Mountjoy et al., 2018). Seventy percent of metabolism is concerned with maintaining physiological functions; it would be useful if healthcare professionals are aware of an athlete's calorie input, calorie expenditure and maintenance calories for an at-

rest state to reduce the risk of LEA. Calories are essential for functions such as cellular respiration, body temperature regulation, the deliverance of blood and nutrients to the tissues, and cellular repair (Nice, 2019).

### 2.3.5 Iron deficiency

Iron is essential for the production of red blood cells and oxygen to be carried around the body effectively. It is not uncommon for athletes to have iron deficiency contributing directly and indirectly to energy deficiency (Mountjoy et al., 2018). Iron deficiency may develop due to an athlete reducing their calorie intake, which decreases metabolic fuel efficiency. Iron deficiency can negatively impact bone health via dysregulation of the growth hormone/insulin growth factor 1 axis, hypoxia, and hypothyroidism. Iron plays a vital role in fertility, thyroid function and psychological well-being (De Souza et al., 2017).

### 2.3.6 Growth and development

Even post anorexia recovery, an athlete they may never reach full growth potential due to early physiological damage, reducing the ability to grow and develop naturally (Mountjoy et al., 2018). Insufficient fuelling can negatively influence the development of an athlete's stature, potentially delaying puberty and ultimately leading to menstrual dysfunction (Purcell., 2013).

### 2.3.7 Cardiovascular function

Early atherosclerosis may be associated with low oestrogen levels in young athletes. Endothelial dysfunction and unfavourable lipid profiles have been associated with athletes suffering from amenorrhea (Rickenlund et al., 2005). In athletes with severe LEA and AN, significant cardiovascular alterations to the body have been identified; including abnormal

heart valves, pericardial effusion, severe bradycardia (not associated with fitness levels), hypotension and arrhythmias (Mountjoy et al., 2018). If left untreated or undiagnosed, cardiovascular conditions could result in premature death (Corrado et al., 2005).

### 2.3.8 Gastrointestinal function

Gastrointestinal tract function (e.g. sphincter function, gastric emptying delay, constipation) may be altered due to LEA and AN. RED-S related gastrointestinal tract symptoms include bloody diarrhoea, vomiting, nausea and abdominal angina – restricted blood supply to the abdominal organs and tissues causing pain / discomfort (de Oliveria et al., 2014). Jeukendrup et al., (2000) identified that long-distance triathletes had increased risk of gastrointestinal complications, which they observed in 29 ultra-endurance athletes. Blood samples were collected from 29 athletes, 1hour, 2hour and 16hours, after competing. The results found 93% had gastrointestinal complications, 45% of which were severe and 7% had to withdraw from their race due to gastrointestinal distress (Jeukendrup et al., 2000). This study was only performed on a small sample of male athletes and there was no comparison made between non athletes which is a limitation to this study. However, similar findings have been found in female athletes too (Jeukendrup et al., 2000).

Ackerman et al. (2018), completed a cross-sectional study of LEA consequences in 1000 athletes (15-30 years old). An online questionnaire was used to classify athletes as having low or adequate EA. The results found athletes with LEA compared to adequate EA, were more likely to have GI dysfunction which can affect the athletes' health and performance consequences (Ackerman et al., 2018).

### 2.3.9 Immunological function

The immune system is comprised of cells and organs which identify and recognise foreign bodies such as a virus, bacteria, or parasites within the body, which it then destroys (Nicholson., 2016). Low energy availability (LEA) may alter the immune system, causing symptoms of frequent and recurrent respiratory complications (e.g. pneumonia), inflammatory infections of internal organs, blood disorders (e.g. low platelet count or anaemia), digestive difficulties and delay in growth and development (Medical News Today., 2019).

### 2.3.10 Psychological function

Athletes with low energy availability not only suffer physical complications but also can be affected psychologically (Mountjoy et al., 2018). Both male and female athletes can suffer psychological alterations due to longstanding LEA, which can impact upon sports performance and on the athlete's daily life (Logue et al., 2017).

Rice et al., (2016) conducted a systematic review highlighting that elite athletes are at greater risk of developing mental health issues which can be a symptom of RED-S. One study had researched the prevalence of mental health disorders amongst n=100 elite athletes in Australia (Gulliver et al., 2015). This study found that 15% of elite athletes had a social phobia, 34% had depression, 26% had self-reported depression and anxiety, and 23% had anxiety disorders (Gulliver et al., 2015). This systematic review recommended that future research should be undertaken on mental health and athlete's wellbeing (Rice et al., 2016), indicating the importance of this thesis research focusing the psychosocial and psychological implications RED-S have on athletes including their mental wellbeing.

## 2.4 Assessment of RED-S in athletes

### 2.4.1 Disordered eating

A shortened version of the Eating Disorder Examination (EDE-Q) is recommended to identify an athlete at risk of an ED, the higher the score, the more severe the ED (Rø et al., 2015). The self-reported questionnaire is composed of four subscales; weight concern, shape concern, dietary restraint and eating concern which creates a global score, a mean of the four subscales, helping to identify if an athlete has an ED and to what extent (Luce et al., 1999). However, Berg et al., (2010) suggested the self-reported questioning may not be a robust method of measuring ED as it relies upon subjective self-reporting which may be subject to bias. Self-report increases the risk of participants altering their answers to please the researcher. The EDE-Q is not an individualised method of investigation and therefore, may result in misdiagnosed or underdiagnosed in athletes that do not meet specific criteria (Berg et al., 2010).

### 2.4.2 Low bone mineral density

Low bone mineral density is measured using a Duel-Energy X-Ray absorptiometry (DEXA) scan. A DEXA scan measures bone mineral content through two x-ray beams, with different energy levels. The soft tissue is absorbed and subtracted out of the image so that the density of the bone can be determined. This can be referred to by the physiotherapist working with athletes (Blake et al., 2007) and appropriate referrals will only be made if physiotherapists are aware of the clinical signs of LBMD as a symptom of RED-S. The bone density test results performed to identify the levels of osteoporosis are reported by a T-score. A score of -2.5 or less indicates the severity of the osteoporosis. Osteopenia is the early stage of osteoporosis and is defined by a T-score of -1.0 to -2.49, which is less severe than osteoporosis and can be reversed with supplements boosting bone turn-over and increasing

bone strength. Physiotherapists should be trained to identify RED-S and have their knowledge and awareness tested, so athletes and patients are appropriately managed (Boniface., 2018).

### 2.4.3 Hormone Imbalance and menstrual dysfunction

If an athlete informs their HCP they have irregular periods, blood tests can assess an athlete's thyroid, oestrogen, testosterone, and cortisol levels. Saliva tests can detect levels of oestradiol, progesterone and testosterone (Kloss et al., 2018). Hormone imbalance occurs due to under or over productive hormone levels (Huizen et al., 2018). Hormone imbalances can cause psychological and physical symptoms such as fatigue, heart palpations, irregular blood sugar levels and mood swings (Huizen et al., 2018). Healthcare professionals should be aware that athletes presenting with such symptoms may be suffering from a hormone imbalance and screen for this.

### 2.4.4 Metabolic rate

To measure an athlete's metabolic rate, a 24-hour assessment is typically performed to investigate the number of calories expended at rest. Basal metabolic rate (BMR) is the rate of energy expenditure per unit by rest. There are two formulae used for men and women to calculate BMR: Men: BMR = 88.362 + (13.397 x weight in kg) + (4.799 x height in cm) - (5.677 x age in years), Women: BMR = 447.593 + (9.247 x weight in kg) + (3.098 x height in cm) - (4.330 x age in years) (British Nutrition Foundation., 2019). A non-invasive Multibreather machine can also be used to capture and analyse the composition of breath. (KORR Medical Technologies Inc. 2019). A physiotherapist can be trained in taking and reading metabolic rate, emphasising the importance of physiotherapists awareness of RED-S symptoms.

### 2.4.5 Iron deficiency

It is crucial to educate any HCP working with athletes on the symptoms of iron deficiency, including fatigue, shortness of breath, difficulty concentrating, muscle weakness and irregular or fast heartbeats (Huizen et al., 2019). Haematology tests include assessing blood disorders and formation, following this a total number of red and white blood cells and platelets can be observed through a blood film and reviewed under a microscope (Mandal et al., 2019).

### 2.4.6 Growth and development

An athlete's growth and development are measured from body composition and anthropometric measures in athletes, through weight in kilograms and height in meters (Santos et al., 2014). Assessments are both longitudinal and cross-sectional so athletes can be measured against other athletes of the same age. Santos et al. (2014) measured n=898 athletes (264 females and 634 males), anthropometric variables were assessed, and DEXA scans were used to generate reference percentiles as a helpful tool for sports professionals.

### 2.4.7 Cardiovascular function

There are numerous methods of screening used for cardiovascular conditions, as reported by Krause et al. (2018). Electrocardiograms (ECG) that measure heart electrical impulses can be used to assess abnormal arrhythmias. X-Rays and echocardiogram (ultrasound) are an effective and efficient way of determining any abnormalities with the heart's valves and chambers (Krause et al., 2018). Blood tests can assess for muscle damage to prevent heart attacks and allow for measurements of substances such as cholesterol and triglycerides, vitamins, and minerals (Krause et al., 2018). Coronary angiography is the most commonly

used post-heart attack or heart angina to assess whether arteries have become clogged or blocked. Magnetic Resonance Imaging (MRI) offers a non-invasive way of assessing heart muscles (Krause et al., 2018). Exercise stress tests are used mainly for athletes where an ECG is in situ whilst the athlete completes a specific exercise such as running on a treadmill to assess how the body copes with the stress of exercise (Krause et al., 2018). This can be particularly useful for rowers, as the rowing ergometer has been used for many years to enable accurate testing (Van Alsté et al., 1985). Physiotherapists do not perform cardiovascular tests however, they can make appropriate referrals if symptoms are identified.

Whilst exercise has health benefits, a 2016 review reported on young athletes with underlying cardiac conditions who then had sudden cardiac death (SCD) and coronary artery disease (CAD) (Wasfey et al., 2016). The study looked at causes, testing and screening in different countries and found some athletes may not present with symptoms of cardiovascular disorders and may go undetected. Therefore, early athlete screening as mandatory is crucial, to identify at-risk athletes, so appropriate care is provided. This study also suggested increasing defibrillator training even at the community level to reduce SCD and CAD in athletes (Wasfy et al., 2016).

### 2.4.8 Gastrointestinal function

Whilst a physiotherapist will not traditionally test gastrointestinal changes, it will be useful they are aware of when to refer a patient to another health professional, due to their symptoms. Once referred, standard testing is through upper gastrointestinal endoscopy and colonoscopy, involving an endoscope down the patient's oesophagus, into their stomach and duodenum, to screen for abnormalities such as GI tract bleeding (NHI, 2019).

### 2.4.9 Immunological function

An immune disorder can be diagnosed from blood tests, to see if an athlete has the correct levels of immunoglobulin and to measure the blood and immune system cells including T-Cells, B-Cells, NK Cells, monocytes/macrophages and neutrophils (Nieman et al., 2019). Abnormal levels can indicate an immune defect (Nieman et al., 2019). Whilst traditionally physiotherapists don't refer for blood tests, they should be aware of symptoms of a weakened immune system and refer a patient to a medical practitioner if a blood test is indicated.

### 2.4.10 Psychological function

An athlete can be tested through the self-reported questionnaires such as 'The Athlete Psychological Strain Questionnaire', which may be beneficial in early identification of athlete psychological strain which can be monitored by the HCP to provide management strategies (Rice et al., 2019). There are nearly 300 mental health disorders listed in the Diagnostic and Statistical Manual of Mental Health used by HCP's to identify and diagnose disorders (American Psychiatric Association, 2013). The most common mental health disorder athletes suffer with are anxiety, eating disorders, body dysmorphia and substance use disorders. Whilst the exact cause is unknown, the pressures athletes face can increase their risk of psychological disorders. A 2019 cross-sectional study investigated self-reported levels of anxiety and depression (Pluhar et al., 2019), 756 athletes aged 6-18 years participated. The results found 13% of athletes competing in individual sports reported anxiety and depression compared to 7% of team sport athletes (Pluhar et al., 2019) highlighting the importance of early psychological detection to ensure athletes continue to participate in sports to reduce long-term psychological disorders and how athletes not in a team are more at risk of poor mental health.

## 2.5 Management of RED-S

### 2.5.1 LEA

Treatment for correcting athlete energy availability (EA) is through education, hence the importance of education for HCP's working with athletes (Boniface., 2018). Physiotherapists are not qualified nutritionists; however, they should provide necessary advice regarding a balanced diet, including vitamin D and calcium to help bone profile (Boniface., 2018). Physiotherapists are trained in understanding the different energy systems. They should educate athletes on this, encouraging them to eat a range of food, including fats, carbohydrates, and protein to support the relevant energy systems. Physiotherapists should be educated on signposting athletes to further information; for example, a referral to a sports medicine doctor, a dietician, endocrinologist and a psychologist regarding DE (Boniface., 2018). Treatment for LEA requires a team approach, including the athlete, coach, physiotherapist, sports physician, sports dietician, physiologist, and psychologist (Mountjoy et al., 2019).

### 2.5.2 Disordered eating

Once DE has been established through assessment, there are different management options, including cognitive behavioural therapy (CBT) which is the leading evidence-based treatment for disordered eating (Murphy et al., 2010). Cognitive behavioural therapy works by altering the athlete's psychology with three stages which involve behaviour modification, cognitive restructuring and progressive learning. The treatment usually requires weekly 30-60 minute sessions over 12-20 weeks (Murphy et al., 2010). Medication including antidepressants or mood-stabiliser medication can be useful alongside psychological

treatment which includes nutrition advice, psychodynamic, interpersonal, and family therapy (treatment and eating disorders, 2020).

A comprehensive narrative review (Joy et al., 2016) identified a multidisciplinary team should lead treatment for ED and DE to ensure an appropriate return to play with the use of evidence-based guidelines to ensure healthy participation in sport. A study within this review (Sykora et al., 1993) identified 12% of male rowers reported at least two binge-eating episodes per week, 3% had self-induced vomiting, and 57% had extreme weight fluctuation and fasting compared to 25% of female rowers. Sykora et al., (1993) highlighting the severity of DE within rowers and the importance of appropriate management.

### 2.5.3 Low bone mineral density

Treatment for LBMD is predominantly through educating athletes. A literature review between 1986 and 2016 (Goolsby et al., 2016), concluded that to maintain and restore optimal bone health, treatment must be focused on restoring normal levels of vitamin D, calcium and ensuring hormones are balanced. Research shows, if BMD is compromised this can lead to long-term implications both physically and psychologically. By educating athletes on the importance of a nutritionally balanced diet, it can improve longevity in sport as LBMD combined with high exercising levels may lead to forced early retirement from sport and potential long-term BMD complications (Goolsby et al., 2016, supported by Boniface., 2018). Depending on the severity of LBMD, medication can be prescribed (e.g. alendronic acid, which increases BMD intending to treat osteoporosis and reduce fragility fractures) (Shaw., 2010). Once an athlete has been identified with LBMD, constant monitoring is required with regular check-ups, blood tests measuring hormone levels and

DEXA scans measuring BMD. Regular check-ups reduce the risk of early return-to-play injury and reduce the risk of fractures by 50-80% (Goolsby et al., 2016).

### 2.5.4 Hormone Imbalance and menstrual dysfunction

Treating hormone imbalance in athletes includes nutritional advice and hormone medication therapy (such as oestrogen therapy and progestin therapy), to ensure that appropriate nutrients are consumed and absorbed, and to regulate a women's hormones (Wright et al., 2008). A common misconception amongst athletes is that the oral contraceptive pill (OCP) will regulate hormones/menstrual cycle and can be used as a treatment for LBMD and some research has found OCP users have 1% less gain in BMD in their spine than those not using OCP (HCP Live, 2011) However, evidence shows that the OCP bleed is due to withdrawal from the pill rather than shedding of the uterus, as the OCP is metabolized in the liver and therefore unable to offer adequate bone protection (Wright et al., 2008).

A randomised controlled trial (RCT) investigated hormone therapy effects on BMD in athletes with menstrual dysfunction, including amenorrhea (Dadgostar et al., 2018). Eighteen female athletes with a $\geq$2-year history of functional hypothalamic menstrual disorder were selected. Participants were randomly allocated into two groups, n=10 participants received a low dose of OCP (containing 30 µg ethinyloestradiol and 150 µg levonorgestrel), and n=8 participants were in the control group who did not receive OCP, all participants received 1000 mg/d calcium and 4000 IU/d vitamin D. Bone mineral density and certain cardiovascular risk factors were measured before and after 9-months. Participants had 1 telephone call every 3 months monitoring drug compliance and potential side effects. The results found the OCP increased participants cardiovascular system however, it did not significantly change their BMD and therefore, is not an appropriate or effective way of

treating hormone imbalance and LBMD. The limitation of this study is that participants were Iranian female athletes only, and the sample size is small, so the data is not representative of the general athletic population. However, this research could prompt further in-depth research for a broader target population.

### 2.5.5 Metabolic rate

Treatment for metabolic disorders involves nutritional advice post-assessment, the HCP can develop a healthy rehab calorie prescription programme individualised for an athlete depending on whether they must maintain, lose or gain weight (KORR Medical Technologies Inc. 2019). An athlete's calorie intake for their training can be calculated once their BMR has been established and advice can be given regarding nutrition timetables and lifestyle advice to facilitate the athletes calorie need for their sport (British Nutrition Foundation., 2019)

### 2.5.6 Iron deficiency

Iron deficiency is treated through iron medication tablets, and vitamin C to improve absorption of iron (Physiopedia, 2020). Anaemia is a condition caused by haemoglobin dropping below 7.0 grams (g) per decilitre (dl) which can result in iron deficiency, affecting up to one-third of the global population (Physiopedia, 2020). In conjunction with medical management, a physiotherapist can offer effective patient education on nutrition and individualised return-to-play. The symptoms of anaemia include fatigue, muscular weakness, shortness of breath and poor circulation, which can all be exacerbated if an athlete continues to overtrain and under recover (Physiopedia: Anemia, 2020).

### 2.5.6 Growth and development

If educated on the usual progression of growth and development, physiotherapists may be able to identify growth and development issues in adolescence (Boniface, 2018). After identification, a physiotherapist can advise on age-appropriate strength and conditioning to reduce the risk of growth plate damage and injury risk. A physiotherapist can provide biomechanical movement analysis and advice to ensure safe movements during sport so as not to affect adolescence growth and provide nutritional guidance to enhance musculoskeletal development (Mountjoy et al., 2018).

### 2.5.7 Cardiovascular function

Cardiac rehabilitation involves exercise training, physiological analysis, psychological analysis and lifestyle advice on nutrition, sleep and overtraining in athletes to prevent excessive heart strain (Physiopedia: cardiac rehabilitation, 2020). A physiotherapist plays an imperative role in cardiac rehabilitation by preventing and managing effects of cardiovascular disease. A physiotherapist can create an age, weight and height appropriate training programme to enhance their cardiac function (Physiopedia: cardiac rehabilitation, 2020).

### 2.5.7 Gastrointestinal function

Treatment of gastrointestinal issues include medication, physical therapy to reduce bloating (trapped air in the GI tract) manually and constipation, and advise on exercise and nutrition (Physiopedia: Gastric Disorders, 2020). There are many different gastric disorders including Celiac disease, Cholecystitis, Crohn's disease, Peptic Ulcers, Pancreatitis and Irritable Bowel Syndrome. The above conditions are inherently inflammatory disorders and may not have a cure; however, a physiotherapist can help with symptoms such as low back pain and reduce the risk of osteoporosis by advising on weight-bearing strength training (Physiopedia: Gastric Disorders, 2020).

### 2.5.8 Immunological function

An option of treating immunodeficiency is stem cell transplantation to ensure continuous renewal of blood cells to reduce infection, modulation of the immune system, enhance tissue regeneration and development as well as optimising homeostasis and wound repair ensuring optimal physiological protection (Williams et al., 2008). Stem cell transplants aim to encourage the production of red blood cells and allow recognition of abnormal cells in the body (Williams et al., 2008). A physiotherapist can be part of a collaborative MDT in treating immune disorders, however severe, as they can encourage exercise prescription to increase the cardiovascular system and advise on an active, healthy lifestyle with a balanced diet (Physiopedia: Autoimmune Diseases, 2020).

### 2.5.9 Psychological function

The best treatment for psychological disorders is psychotherapy, including cognitive behavioural therapy, interpersonal therapy and psychodynamic therapy performed by a trained sports psychiatrist (Cohn, 2020). To optimise an athlete's recovery from a psychological disorder, a multidisciplinary team should be involved to ensure a collaborative

approach is taken (Cohn, 2020). A physiotherapist is well placed to refer to a psychologist or psychiatrist if they suspect severe psychological changes in athletes (Reardon., 2016). Sports psychology is beneficial for successful development of athletes, and there is growing interest in the development of athlete-specific screening and identification to help early identification of mental health problems (Donohue et al., 2019).

### 2.5.10 Return to Play

Suitable medical diagnosis and management of RED-S may be most effective when led by a trained HCP. Research suggests clinical management and an athlete's Return-To-Play is most appropriate when a collaborative approach is taken by the medical team, athlete and coach. The RED-S Clinical Assessment Tool (CAT) was developed in 2015 following the release of the IOC Consensus Statement (2014), so HCPs could evaluate an athlete ensuring appropriate and safe RTP (Mountjoy et al., 2015).

The RED-S CAT acknowledges that screening and diagnosing RED-S can be challenging as symptoms can be subtle. However, a particular focus on the athlete at risk is required. It has been recommended that RED-S screening should be undertaken as part of an annual 'Periodic Health Examination', mainly if the athlete presents with an ED (Mountjoy et al., 2015).

The RED-S CAT tool is the clinical diagnostic tool for trained HCPs relies upon the clinician to make a clinically reasoned and appropriate decision for each athlete (Mountjoy et al., 2015). More recently it has been suggested a RED-S red flag set question checklist should be created for BMD, as there are with other medical conditions, such as cancer and cauda equina screening (Boniface, 2018). To enhance appropriate athlete management, Red Flag

screening questions used in the future could ensure appropriate referrals for a DEXA scan, for example (Boniface, 2018).

A RED-S Risk Assessment Model was created in 2015 by Mountjoy et al., for HCPs (*figure 2.5.1*). The RED-S 'Red-Light Yellow-Light Green-Light' was designed to assist with medical management for athletes. This risk assessment model was developed to facilitate the clinical assessment and enhance an HCP's decision making as to whether an athlete should continue to participate in the sport in relation to their current health status. The RED-S CAT Assessment Tool allows all HCPs flexible parameters so it can be suited to individual athletes and sports, ensuring appropriate diagnosis (Sundgot-Borgen et al., 2015). Athletes with 'High risk' of RED-S will receive a 'Red Light', meaning they are not medically clear to participate in sport and require immediate treatment to enable recovery. A 'Moderate risk 'Yellow Light' represents athletes allowed to patriciate with close supervision and a medical treatment plan. Low risk 'Green Light' deems an athlete as healthy and able to participate in sport (Mountjoy et al., 2015).

***Table 1 RED-S CAT Risk Assessment Tool (Modified from Mountjoy et al., 2015)***

| **High Risk = No participation in Sport RED LIGHT** | **Moderate Risk= Caution for participation in Sport YELLOW LIGHT** | **Low Risk= Can continue to participate in Sport GREEN LIGHT** |
|---|---|---|
| *Severe eating disorders, e.g. anorexia nervosa.* | *Prolonged abnormal low body fat percentage (could be measured through a DEXA scan).*<br><br>*Intentional and substantial weight loss (e.g. 5-10% of body mass in 1 month).*<br><br>*Insufficient growth and development for the age of the adolescent athlete.* | *Healthy, balanced eating habits with appropriate energy availability.* |
| *Severe medical conditions related to low energy availability (physical and psychological).* | *Abnormal/irregular menstrual cycle.*<br><br>*Menarche over the age of 16 years.*<br><br>*Abnormal hormone profiling (men and women).* | *Normal hormonal and metabolic function (e.g. regular menstrual cycle for women and a regulated motivational drive for men).* |
| *Extreme weight loss and dieting techniques used in and out of the sport. Resulting in dehydration, unstable haemodynamic and other potentially life-threatening conditions.* | *Reduced bone mineral density.*<br><br>*History of recurring stress fractures.* | *Healthy bone mineral density for age, height, the ethnicity of the athlete.* |
| | *The athlete with physical and or psychological complications related to LEA which could be visible on questionnaires and or physical tests such as an Electrocardiogram ECG.*<br><br>*Prolonged relative energy deficiency.*<br><br>*Overtraining syndrome / under-recovery symptoms.*<br><br>*Lack of progress in training or treatment.*<br><br>*Disordered eating negatively affecting other members or being notified by other members of the team.* | *Healthy musculoskeletal system.* |

Regarding decisions to return to sport, a RED-S Assessment Decision Making for Determining Readiness for return to play was created *(figure 2.5.2).* This model was designed for a trained HCP working with an athlete as a step-by-step guide to ensure a time appropriate and medically safe return to play (Mountjoy et al., 2015).

***Table 2 RED-S, Return to Play, Step by Step model (Modified from Mountjoy et al., 2015)***

| Steps | Risk Modifiers | Criteria | RED-S Specific Criteria |
|---|---|---|---|
| **STEP 1 Evaluation of Health Status** | MEDICAL FACTORS | - *Patient demographics (e.g patient name)*<br>- *Signs and Symptoms*<br>- *Past Medical History*<br>- *Diagnostic tests (e.g. blood test)*<br>- *Psychological test (e.g. disordered eating questionnaire)*<br>- *The potential seriousness of symptoms and test results* | - *Age, sex*<br>- *(Use yellow column of RED-S Risk assessment model)*<br>- *Regular dieting, irregular menstrual health, bone-healthy*<br>- *Intentional weight loss/fluctuation*<br>- *Health profiling tests, e.g. DEXA scan and hormone profiling*<br>- *Abnormal hormonal and metabolic function*<br>- *Stress fractures*<br>- *Cardiac arrhythmia, e.g. heart palpitations*<br>- *ED, DE, depression, anxiety*<br>- *Abnormal metabolic and hormone function* |
| **STEP 2 Evaluation of athlete and their risk** | SPORT RISK MODIFIERS | - *Sport type*<br>- *Position or role within the sport*<br>- *Competition level* | - *Weight dependent (e.g. lightweight rowing) leanness sport (e.g. ballet)*<br>- *Individual vs team sports*<br>- *Elite vs recreational sports* |
| **STEP 3 Decision making** | DECISION MODIFIERS | - *Timing and season type*<br>- *Competitions*<br>- *Internal pressure from the athlete*<br>- *External forces, e.g. coach, parent*<br>- *Conflict of interest*<br>- *Fear of speaking out* | - *Timing within the season (in or out of competition)*<br>- *Travel, environmental, social factors*<br>- *Mental capability and readiness to complete*<br>- *Coach, parent, team, sponsor support*<br>- *Competition restrictions* |

## 2.6 Implications of RED-S

### 2.6.1 Potential short and long-term implications of RED-S

The short-term health implications of RED-S can impact upon male and female athletic performance as reported in the most updated narrative review by Logue et al., (2020), the articles used were published between 2017-2019 and all focused-on EA. The results of this narrative review identified the common issues athletes suffer with as a result of LEA (a symptom of RED-S): reduce athlete energy, cause impaired judgement, decreased neuromuscular function, reduce mental capacity, impair optimal muscle mass growth, whilst also causing damage to the endocrine system (Logue et al., 2020). However, this study does not report upon an athlete's perspective of living with RED-S, nor does it explicitly state what sports the athletes are involved in. Additionally, males and females with RED-S can experience reduced levels of testosterone, disruption in the pituitary gland, hormone imbalances (e.g. decreased leptin), regulation changes to temperature, reduced levels of insulin, increased growth hormone resistance and increased levels of cortisol, all of which can impact upon normal bodily functions and emotions (Mountjoy et al., 2018).

If undetected or untreated, the impairment in body functions can have long-lasting negative health implications such as infertility due to unbalanced hormonal process, osteoporosis due to LBMD and a depressed immune system due to insufficient nutrition (Mountjoy et al., 2018). The long-term psychological implications include mental health issues around anxiety, social isolation, and disordered eating (Dudgeon, 2019).

A common feature of RED-S is DE. If left untreated DE can increase the risk of many diseases such as cancer and inflammatory disorders and has been strongly associated with

cell death of the hippocampus potentially resulting in early Alzheimer's due to oxidative stress (Hu et al., 2013).

## 2.7 Lightweight Rowing

### 2.7.1 Lightweight rowing and RED-S

Athletes and non-athletes of any age can be at risk of RED-S if they have a high EE and a low-calorie input causing LEA. However, some sports place athletes at higher risk; including weight-dependent sports requiring athletes to maintain a certain weight for competition and aesthetic or leanness sports where being lean is seen as an advantage (Keay, 2019). Lightweight rowing is a weight-dependent sport where participants have an increased risk of developing RED-S. Lightweight rowers are required to be 'weighed in' 2 hours before every race to compete. For summer international races, female rowers are required to weigh 57kg and men 70kg (Britishrowing.org, 2019) and therefore, are at risk of RED-S due to weight restrictions and dieting. A systematic review from 2013 (Werner et al. 2013) identified athletes in weight controlled and leanness sports (including lightweight rowing), resort to extreme dieting, excessive exercise, using regular laxatives and diuretics as well sweat loss routines, vomiting and diet pills before weighing in. This systematic review concluded that athletes have a higher prevalence of weight concerns and weight-control behaviour than non-athletes. This review highlighted that extreme pathogenic weight-control action often leads to clinical eating disorders, a symptom of RED-S, and can spiral into other psychological disorders, such as anxiety and physical disorders (Werner et al., 2013).

There is limited research on RED-S in lightweight rowers, and the exact prevalence of RED-S in lightweight rowers is yet to be identified. Dimitriou et al, (2014) investigated n=29 female rowers $\geq$18 years, of which six reported DE from intentional weight loss. This study aimed

to determine how LBMD, DE, training history, national (or international) weight loss and rib pain/back pain is associated with lightweight rowers. The results found 6 had DE, 17 had a history of amenorrhea, and 7 participants had rib or spine pain. A DEXA demonstrated that 12 rowers had LBMD (Dimitriou et al., 2014). This article suggested a lack of nutritional support and education for the lightweight rowers as there was insufficient awareness of LEA. Whilst there is a small sample size used, the high proportion of athletes who suffered from RED-S symptoms in this small target group, suggests it may be shared amongst lightweight rowers. This study is limited by only looking at lightweight rowers in the UK; the results may vary in different countries.

## 2.8 Physiotherapists

### 2.8.1 Physiotherapist's knowledge and awareness of RED-S

Awareness is key to prevention of RED-S. However, an article by Keay (2018), identified less than 50% of physiotherapists could identify components of F.A.T. and a lack of awareness of RED-S is even more common (Keay., 2018). An earlier study from 2006 determined that out of N=240, HCP (physiotherapists, physicians, athletic trainer and coaches) only 48% of physicians, 43% of physiotherapists, 38% of athletic trainers and 8% of coaches were able to identify all three components of F.A.T.. The components of F.A.T. are within RED-S; therefore, this data can be used to suggest the knowledge of RED-S may also be poor (Troy et al., 2006).

A physiotherapist is a trained HCP who helps patients, of any age affected by injury, illness or disability through movement and exercise whilst providing education and advice for patients so they can manage their condition. They also work to manage pain and prevent disease and injury (The CSP, 2019). Physiotherapists have been working with elite athletes

for many years and are an integral part of the sports medicine team. At the London 2012 Olympic Games, physiotherapists formed the most extensive professional group working at the Games (Physiopedia, 2019). They play an essential role in recovery, injury and illness prevention and athlete maintenance (Barrett., 2019). Hence educating physiotherapists on the current evidence related to athlete injuries and disease, including RED-S, is of great importance to ensure appropriate medical care.

Studies have investigated the knowledge and awareness of RED-S among physiotherapists in countries other than the UK. These studies found understanding was limited, and education must improve on optimising athlete quality of care. Ashby (2019) investigated the awareness of RED-S and LEA in Physiotherapists in New Zealand. Out of 95 physiotherapists that responded to a questionnaire, less than 55% were aware of RED-S and LEA. 46% were aware of LEA but were unable to distinguish a difference between LEA and negative energy balance. This study suggests that physiotherapists in New Zealand have insufficient knowledge of RED-S and are unable to recognise symptoms (Ashby 2019). Whilst this study cannot be generalised to UK Physiotherapists, it can be used to highlight a potential gap in physiotherapists' education.

Similar findings were demonstrated in 2015 by Curry et al. (2015), who identified only 37% of 931 physicians had ever heard of F.A.T.. The limitation of this study is, it does not state where the physicians were from, and therefore, what target population the findings can be generalised to. However, 51% reported they would feel comfortable treating or referring a patient who had symptoms of the F.A.T. The mismatch between F.A.T knowledge and comfort managing F.A.T is concerning and questions the quality of management delivered.

Whilst this study is on F.A.T., the findings can support the research of RED-S, as F.A.T symptoms are an indicator of RED-S(Curry et al., 2015).

Physiotherapists are integral to competitive rowing, as an injury is almost inevitable during a rower's career due to the excessive load, demand and training placed on the body (Thornton et al., 2016). With this unreasonable load combined with inadequate calorie intake due to weight restrictions in rowing, the athletes have a high risk of RED-S. A collaborative approach should be taken by the HCPs working with athletes suffering from RED-S involving a multidisciplinary team of Physicians, Physiologists, Physiotherapists, Nutritionists, Sports Psychologists, as well as the athlete, the athlete's parent and coach (Mountjoy et al., 2018).

# Chapter III Aims

## 3.1 Aims

Currently no research qualitatively explores the knowledge and management of RED-S amongst physiotherapists (Physiospot, 2019) who work within high-risk sports such as lightweight rowers. Furthermore, there is no research investigating the psychosocial implications that RED-S has on lightweight rowers from their perspective. Therefore, this is an innovative study.

This study primarily aims to investigate the physical and psychosocial impact of RED-S from the personal perspective of lightweight rowers in the UK. The second aim is to examine the knowledge, awareness and management of RED-S in lightweight rowers and physiotherapists working in lightweight rowing in the UK.

# Chapter IV Methodology

## 4.1 Methods

### 4.1.1 Study Design

This study is reported in accordance with the Consolidated Criteria for Reporting Qualitative Studies (COREQ) guidelines (Tong et al., 2007). It has been approved by the University of Oxford Medical Sciences Interdivisional Research Ethics Committee (ethics ref: R67265/RE001). No funding was received for this research.

### 4.1.2 Participants

It was estimated that approximately 10-12 lightweight rowers (male and female, both considered to broaden the study findings, most RED-S research is focused on either males or females) and 10-12 physiotherapists would be required to address the aims of this study. The point of data saturation (where no new information was discovered through the data analysis) determined the actual sample size; whereby no new themes /arise from two consecutive interviews (Walker, 2012). Participants were recruited through a sample of convenience via a recruitment poster (Appendix 5 and 6): this was advertised through the social media platform Twitter.

To be eligible, physiotherapists were required to be currently or previously registered in the UK and worked with lightweight rowers for $\geq$1 year. Eligibility criteria for lightweight rowers were: i) aged >18 years, ii) competed in UK lightweight rowing at any standard for $\geq$1 year, iii) self-reported having experienced $\geq$1 RED-S symptom during lightweight rowing.

The lightweight rowers' eligibility criteria enabled a range of participants of different competition levels and ages so that the sample was more representative of the lightweight rowing community. The inclusion criteria for the physiotherapists ensured that qualified and certified professionals were included from across the country. There was no age bracket allowing for a wide age range of physiotherapists to see if their knowledge and management of RED-S differed depending on experience and year of graduation. Lightweight rowers' 'competition level' was based on competition category: elite international - top-level competition against different countries; elite national top-level competition within the country; intermediate - local and national competition racing as an intermediate (British rowing, 2017).

Recruitment posters outlined eligibly criteria. Participant eligibility was confirmed via email before the arrangement of a telephone interview. Participants were then sent a participant information sheet outlining the aim of the study, the researchers involved, what was expected of them and how their data would be stored/used. After this had been sent participant involvement was confirmed.

Informed verbal consent was obtained from each participant at the start of the interview. Participants emailed the primary researcher (LG) a female physiotherapist with elite lightweight rowing experience, to express interest. Participants were then checked against the inclusion criteria ensuring appropriate participation.

Whilst the participants were unable to remain anonymous to the researcher due to the nature of the interview, a pseudonym was used for any personally identifiable data for the transcription and use of quotes.

### 4.1.3 Interviews

Interviews were conducted by one author (LG), a female physiotherapist with four years' experience competing as an elite lightweight rower. The interviewer had no established relationship with participants before interviewing. The semi-structured interviews were designed, developed, and tested through a pilot study of 2 physiotherapists and two lightweight rowers, before disseminating the recruitment posters on social media. Participants who volunteered in the pilot interview were asked the same two questions after completion '1) Do you think the questions are phased appropriately? 2) Do you think the questions will answer the research question(s)?'. No changes were made to the semi-structured interview guide. The semi-structured interview guide contained primarily open-ended questions with relevant prompts to elicit in-depth responses.

One telephone interview per participant was required, the duration ranged between 32-60 minutes. A study journal was used, summarising each interview, and allowing reflection of initial thoughts. All interviews were audio-recorded and transcribed verbatim by the interviewer (LG), informed verbal consent was obtained at the start of the interview. The pseudonym used during transcription, and an alias was aligned to each participant. The interviews were conducted in a private office at the University by the interviewer (LG). The reason for using telephone interviews was for convenience for participants, so they were not required to travel. To eliminate the risk of conflict of interest, both supervisors of this thesis (NA and SF) would listen to the audio recordings to ensure no personal opinions were given during the semi-structured interviews that may alter a volunteers response, this was part of the data collection and analysis process.

The questions in the lightweight rowers semi-structured interview (Appendix 4) addressed the following main areas; i) level of experience within lightweight rowing, ii) how dieting for lightweight rowing affected their relationship with food and exercise, iii) how lightweight rowing and dieting had impacted their daily life such as sleep and concentration. Finally, if they had any knowledge of the term RED-S, and how these symptoms had affected their rowing career, if they had not heard of RED-S before, they would be given a definition and informed about what symptoms this includes.

The questions in the Physiotherapists semi-structured interview (Appendix 3) addressed the following main areas; Firstly, their experience working with lightweight rowers within the UK. Secondly, if they had any knowledge of the term RED-S and if so, how they had acquired this knowledge. If they had not heard of RED-S, they were given a definition and told of the symptoms. Thirdly, their management of the condition RED-S, whether they had the first-hand experience or hypothetically, how they would manage the condition should they come across it.

### 4.1.4 Data Analysis

An inductive analysis approach was used as the author wanted the data to determine the themes, Braun et al., (2006) facilitated the use of this approach. Each interview was thoroughly analysed to reflect the entire data reported by participants, meaning the data was not coded into pre-conceived themes (Braun et al., 2006). Themes were derived from the data, rather than relying on pre-conceptions or theoretical frameworks. The interviewer (LG) read the transcripts multiple times, with and without the accompanying audio-recording, then uploaded all data into NVivo, creating nodes and child nodes to categorise the themes between participants' experiences. NVivo V.11(Bazeley et al., 2013) software

facilitated coding of the transcripts into broad-inclusive categories, generating themes/subthemes of relevance to the study aim, whilst refining for analysis. Codes were sorted into the hierarchical structure; overlapping codes were merged, and codes unrelated to the study aim were filed elsewhere. A second author, experienced in qualitative research (SF) reviewed the data by listening to a few audio-recordings, coding structure and preliminary themes in NVivo V.11 ensuring an accurate representation of the dataset by the interviewer (LG), after which a meeting was held to finalise the coding consensus. Participants were asked at the end of the interview if they would like a copy of the results once analysed.

# Chapter V Investigating the Physical and Psychosocial Impact of RED-S from the Personal Perspective of Lightweight Rowers in the UK

## 5.1 Results

### 5.1.1 Participant Characteristics

Twelve lightweight rowers participated in this study and were aged a mean 22 (range 19 to 32) years, and 8 (67%) were female and 4 (33%) male(Table 3). Six participants had competed in lightweight rowing at an Olympic or international level (50%), two had competed at a national level (17%), and three had competed at an intermediate level (25%). The length of participation in lightweight rowing competitions ranged from 1 to 8 years. Five participants had retired from rowing completely (42%), 4 were previous lightweight rowers who were rowing as a heavyweight at the time of interview (33%), and 3 participants (25%) still competed as lightweight rowers at the time of interview.

***Table 3 Lightweight rower participant characteristics***

| Alias | Sex | Age Range (years) | Year(s) of Lightweight rowing experience | Rowing Status | Competition level |
|---|---|---|---|---|---|
| **AMY** | Female | 19-21 | 1 | Former lightweight* | Elite international |
| **ANG** | Female | 22-24 | 2 | Former lightweight* | Elite international |
| **BOB** | Male | 31-33 | 8 | Former lightweight | Elite international |
| **FRED** | Male | 19-21 | 2 | Former lightweight* | Intermediate |
| **GRACE** | Female | 19-21 | 2 | Former lightweight | Intermediate |
| **MARY** | Female | 22-24 | 5 | Former lightweight | Elite international |
| **MEG** | Female | 19-21 | 2 | Current lightweight | Elite national |
| **MIA** | Female | 19-21 | 2 | Former lightweight | Elite national |
| **PAUL** | Male | 19-21 | 2 | Former lightweight | Elite international |
| **PHILL** | Male | 22-24 | 5 | Current lightweight | Intermediate |
| **PIP** | Female | 22-24 | 5 | Current lightweight | Elite national |
| **TAL** | Female | 22-24 | 2 | Former lightweight | Elite international |

*previous lightweight rowers, now competing in heavyweight rowing

### 5.1.2 Summary of results

All lightweight athletes described restricting calorie intake whilst increasing energy expenditure through excessive exercise and weight-loss tactics, before weighing in. These practices resulted in physical and psychosocial implications (*figure 5.1.1*), persisting beyond lightweight rowing participation. Quotes are used throughout the results chapter to support the themes identified for both gender, additional quotes can be found within tables 4, 5 and 6.

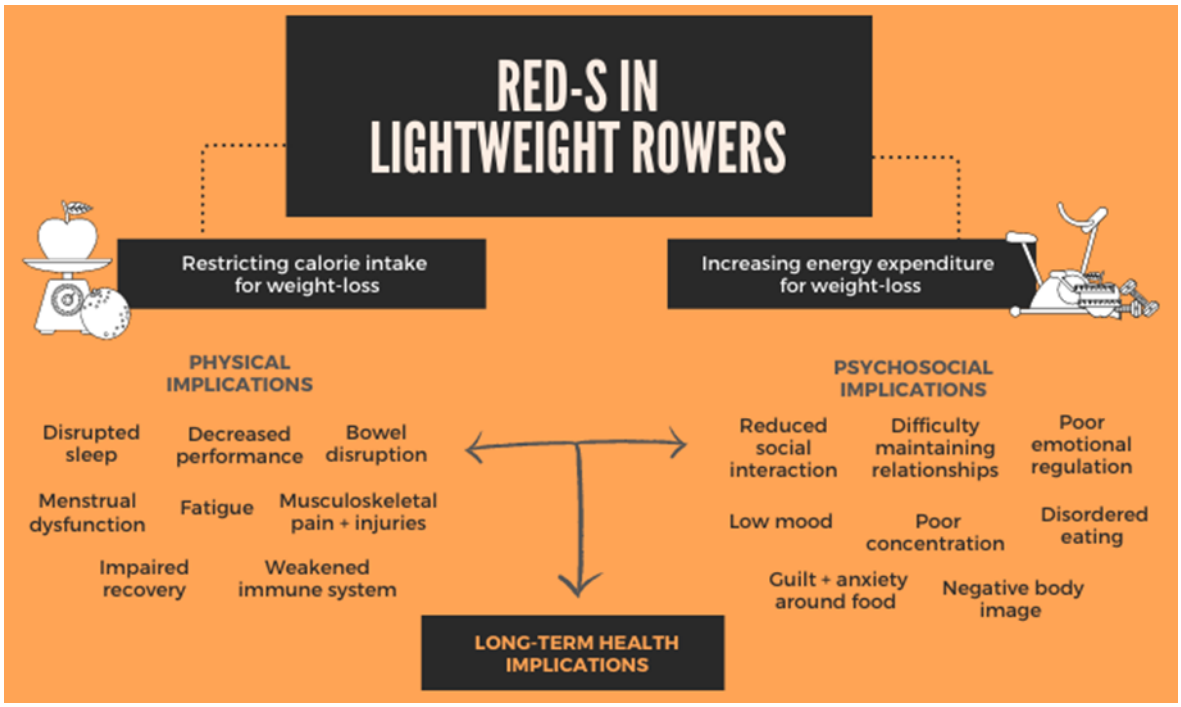


***Figure 1 Summary of the physical and psychosocial impacts of RED-S in lightweight rowers***

## 5.2 Weight Loss

### 5.2.1 Restricting calorie intake for weight-loss

All athletes described restricting their calorie intake to lose weight for lightweight rowing competitions. This involved weight-loss tactics prior to race day where athletes would try to lower their weight through, strict dieting, rituals, routines and fasting in between training for weeks before an event.

> *BOB: 'I kept a training diary for eight years; I would write down every morning and night my weight… I would diet hard, teaching myself what the minimum was my body needed to survive on, everyone starved themselves, there's days when you literally had no food just like three pieces of toast and caffeine in a whole day whilst training three times a day.'*

ANG: ‘I used to skip breakfast and do a long session then I’d have like an apple …I’d make myself wait, so I was probably just running on empty.’

### 5.2.2 Increasing energy expenditure for weight-loss

All athletes increased EE during weight loss before weighing in, involving additional high-intensity cardiovascular exercise on top of 2-3 training sessions each day. Increasing EE was not matched with calorie intake - the mismatch between energy consumption and exertion was seen as desirable and necessary to compete in lightweight rowing. Ten rowers (83%) reported lightweight rowing negatively affected their relationship with exercise, and several felt internal pressure to maintain weight with excessive exercise, even once retired. Most rowers would go through the process of ‘sweating down’ whereby they would exercise before weighing in on race day, wearing layers of clothing to reduce their water weight, causing dehydration.

*AMY: ‘I'd often go for a walk after dinner, to help digestion. I’d drink so much water to keep myself full… before, and after meals, I would do more cardio-based extra exercise, and I wouldn’t do lifting weights in gym or if I did it would be like maintenance weight to reduce the weight I would gain, but anything outside of my training programme was designed for me to sweat…’*

BOB: ‘110% it [lightweight rowing] affected performance, but it was just something you have to do to make weight and race…I hated training because of it, I would be training three maybe four times a day in the peak of summer building up to a race and sometimes eating less than the average person….a lot of training sessions I’d go into feeling pretty knackered… …for a world cup you would have three days of racing and need to be 70kg for three days in a row, sometimes I would need to do extra sweat sessions in between racing or as well as racing to keep the weight off.’

*Table 4* ***Additional quotations illustrating the mechanisms of energy deficiency in lightweight rowers***

| Theme | Participants' Quotes |
|---|---|
| **Restricting calorie intake** | *PAUL: '…I would always be in a constant cutting state, I would never have a way of being able to eat lots of carbs, it was only the week after a competition I would be able to have pasta or a curry for dinner; otherwise it was just salmon and fish and salad. So, I never really made a cut because I was always slowly depleting my calories and just constantly cutting to maintain my weight rather than go up and down.'* |
| **Increasing energy expenditure** | *ANG: 'I was doing a lot more sweaty exercise to help lose the weight, whilst feeling awful at the same time but building up to the big competitions we were doing like three sessions a day, and we would continue to build on this with intensity and length of pieces before tapering just before the race day.'* |

## 5.3 Psychosocial implications

Six themes were identified, demonstrating the psychosocial implications of RED-S in lightweight rowers, additional quotations are presented for each theme in Table 5.

### 5.3.1 Low mood and poor emotional regulation

Many participants felt that hunger and dieting had a negative impact on their mood and their ability to regulate their emotions.

> *MIA: 'I remember I had a driving lesson and I just cried because I was just so flat and really down and I can now look back on it now as something chemically not right because of not eating… I had a cake once because it was my birthday and my mood just changed drastically.'*

*ANG: 'I struggled in lectures because I was so hungry. I got headaches and felt so tired and fatigued. I would wake up and feel groggy and horrible… I felt rubbish and just sad.'*

### 5.3.2 Reduced social interaction and difficulty maintaining relationships

Ten participants believed that lightweight rowing placed a strain on their relationships with friends, colleagues, family, and partners. Many avoided eating out with others as they felt they could not 'afford' to consume the calories.

*PIP: 'I used to stay late a lot on campus, just so I could eat my food by myself. I also would say I can't come out to certain social's because I either needed to do an extra cardio or I couldn't eat anything there.'*
*MARY: 'I didn't go to like any of the rowing socials because I knew I would just sit there and not be able to eat anything which would make me more upset than actually going. I did have so many incredible friendships built throughout my career but when I was dieting my personality just changed, and I wasn't the same person, so it was difficult to maintain those relationships which are built on another type of your personality.'*

### 5.3.3 Poor concentration

Participants described experiencing difficulties concentrating, often attributed to hunger and stress of maintaining a lightweight, negatively impacting their academic/employment productivity.

*PIP: 'It probably shifts your priorities and to what extent you're able to focus… you can't just finish the sport and then compartmentalise because you've got to think about what you're eating throughout the day.'*

*PHILL: 'My job was based around communication. I had less tolerance and concentration levels, so I had to try and do things over email just so I didn't cause drama it gave me a bit more time to think.'*

### 5.3.4 Disordered eating including guilt and anxiety around food

When the participants described their eating habits, five (42%) reported binge eating attributed to food cravings following extreme diet restrictions. This was most evident post-weigh-in for competition. All participants believed the pressure of making weight negatively impacted their relationship with food. Participants experienced anxiety, stress and guilt when eating. All six retired participants expressed their long-term relationship with food was damaged.

*MARY: 'A guilt thing maybe… if I ate a certain amount, I needed to exercise it off. If I had a half-day, I'd feel like I kind of want to do more because I'd feel like I didn't deserve to eat.'*

*PHILL: 'I binged for a couple of days afterwards and I think that probably made it worse with body image and things and then I went back to being like, this isn't acceptable.'*

### 5.3.5 Negative body image

Eleven participants reported lightweight rowing/dieting negatively impacted their body image perception, which continued once retired. Two male participants felt societal pressure to have a masculine physique which they were unable to sustain when losing weight.

Participants described experiencing anxiety and fear following retirement in anticipating how their body shape might change.

> *PIP: 'I definitely experienced body dysmorphia; it disconnects you from what's actually normal… I'm anxious I'm going to look a certain way, it's kind of a fear that I can't stop rowing because of how I should look.'*
>
> *PHILL: 'I think it's worse for men... you're meant to have a certain manly body type, and in summer weight it is the complete opposite… I felt I should feel body negative'*

***Table 5 Additional quotations illustrating the psychosocial implications of RED-S in lightweight rowers***

| Themes | Participants' Quote |
|---|---|
| **Low mood and poor emotional regulation** | *PIP: 'Oh building up to a competition every lightweight is very touchy about the subject of weight so if anyone brings up mealtime, food or appears to be questioning your diet, we would just snap… it can often be very tense to be in a lightweight crew… I was completely different when I was dieting to how my usual personality is.'* |
| **Reduced social interaction and difficulty Maintaining relationships** | *ANG: 'I wouldn't go out for dinner with friends because I knew I couldn't eat anything… my mum got the brunt of it… I don't know how my boyfriend stayed with me.'* |

| | |
|---|---|
| **Poor concentration** | *MARY: 'In my second year, my concentration was definitely worse from being so hungry and thinking of food… I have now split my course year 50% intensity… I was really struggling to make weight, cut, train, along with assignments and exams.'* |
| **Disordered eating including guilt and anxiety around food** | *AMY: 'I can't really look at food in the same way anymore... I only did it [lightweight rowing] competitively for one year, and it just affected me so much. It spiralled when I was racing competitive, I felt self-conscious. It was a yo-yo effect like going from one extreme to another of dieting and binging after racing. I wish I could take back a few years, just go back to how I was previously because there was no issue whatsoever.'* |
| **Negative body image** | *MIA: 'I was never conscious about my weight before I started doing it [lightweight rowing], I'm quite slim anyway, and I've never really been able to put weight on. Now I just have weird things in my head like If I'm hungry I'm like yeah that's good… I want to eat good clean food because it is almost drilled into you, you just want to be the skinny girl.'* |

## 5.4 Physical implications

Six themes were identified demonstrating the physical implications of RED-S in lightweight rowers; additional quotations are presented for each theme in Table 6.

### 5.4.1 Disrupted sleep and fatigue

Ten participants believed dieting disrupted their sleep, compromising energy levels and performance—some experienced irregular sleeping patterns due to reduced calorie intake causing them to wake up hungry, during the night or early morning and would go to sleep early in the evening, distracting the feeling of hunger.

> *MIA: I was so hungry I would wake up absolutely ravenous. I would also go to sleep really, really hungry, and down a litre of squash and then just go straight to sleep. I*

*would try and convince myself I was full, and I would just wake up really, really hungry.'*

*PAUL: 'I couldn't get to sleep because I was so hungry... I would wake up a couple of times I would be so hungry I would have to have a cereal bar or something which I shouldn't really have.'*

### 5.4.2 Decreased performance and impaired recovery

All participants reported training and competition performance was affected by weight loss dehydration. Ten athletes felt unable to recover between sessions, negatively impacting performance.

*TAL: 'It [dieting] really affected our race day performance, we could barely row four kilometres without people going dizzy we would be so tired too. So, it was not healthy, and we were definitely not fuelled.'*

*PHILL: 'I had to adapt my own training programme because I couldn't train enough, well I couldn't eat enough because of dieting to support the training…so we have multiple days of 18k on the erg, and I was having to cut that to 12k because I couldn't finish it without going light-headed and really struggling… I would be really tired all through the session, and then I'd be tired for work…I'd be struggling because I was never recovered.'*

### 5.4.3 Bowel disruption

Ten participants used 'gut clearing' to lose weight, increasing fibre intake two weeks before weighing in then drastically removing the fibre, eliciting frequent bowel movements. Some participants reported this made them unwell, producing 'painful bloating' and 'constipation'.

Only two participants did not report bowel disruption whilst one of the two regularly used laxatives for weight loss and to reduce bowel disruption.

> *MIA: 'In the run-up to weigh in I would obviously cut fibre as well which really upset my stomach, I would get so bloated it would be painful.'*

> *ANG: 'I took so much senokot which is a laxative to lose the weight. But I probably would have a dodgy stomach if I didn't have so many laxatives because I completely cut out fibre when I was gut cleansing.'*

### 5.4.4 Menstrual dysfunction

Five of the eight female participants reported menstrual dysfunction (irregular menstrual cycles, primary and secondary amenorrhea). Three participants used the contraceptive pill to try and correct their disrupted cycles. One participant expressed the pill made them feel anxious, as it masked the cause of the menstrual disruption.

> *GRACE: 'That's when the amenorrhea started for like six months, seven months… I went to the doctors; they were like you need to do less exercise and eat more… you know when someone looks at you and just doesn't understand you'*

> *MIA: 'I had amenorrhea for like 4 or 5 months.'*

### 5.4.5 Weakened immune system

Nine participants described having compromised health whilst competing as a lightweight rower. They reported having experienced a range of health complaints, including recurrent colds, and glandular fever.

> *ANG: 'I was just really unhealthy… I definitely had a few more colds that were harder to shift and wasn't able to eat the best food to help myself recover …I would feel*

*really low and rubbish I'd wake up feeling groggy and horrible which makes you feel mentally horrible as well as physically… '*

*BOB: 'I had glandular fever and got a few nasty colds...very hard to shake off.'*

### 5.4.6 Musculoskeletal pain and injuries

Eleven rowers experienced injuries from lightweight rowing, 10 of which had recurrent injuries. Common injuries included rib stress fractures, intervertebral disc extrusions, generalised joint pain, and chronic wrist and ankle injuries. One retired participant described how his injuries still impacted his daily life and ability to participate in the exercise.

*AMY: 'During the (World Championships) pretty much 90% of my days have been some kind of pain, it did turn out that I actually had fractured it, I raced with a fractured rib... It's not fractured now but I have osteopenia'*

*MIA: 'I got a bulging disc in my back; it was because I was so stripped as a lightweight, I wasn't able to support myself with my muscles… I still have ongoing problems now with my spine because of this… I always got niggles, I was often very ill and took ages to recover'*

***Table 6 Additional quotations illustrating the physical implications of RED-S in lightweight rowers***

| Theme | Participants' Quotes |
|---|---|
| **Disrupted sleep and fatigue** | *PIP: 'I was definitely overtired. I would sleep whenever I could. I did have quite a good routine generally because of rowing, but sometimes if I were really hungry from dieting and stressed about* |

| | |
|---|---|
| | *that and exams I wouldn't sleep as well, and I would wake up in the night hungry.'* |
| **Decreased performance and impaired recovery** | *ANG: 'I tended to yo-yo like 85% of the time with dieting which didn't help my training performance as I would just have like no energy during the sessions and my coach would comment on how awful I looked which I know was due to how little I was eating.'* |
| **Bowel disruption** | *MEG: 'Yes, I had a dodgy stomach. I cut out fibre, and that made it worse… I got bloated quite a lot.'* |
| **Menstrual dysfunction** | *TAL: 'My periods stopped a month into starting rowing in first year, I also wasn't getting enough sleep. I didn't really take notice at first but it didn't come back for 3 years, I have been going to the GP but they didn't help and just said maybe I had PCOS and needed to eat more and they put me on the pill which I know now was not the right thing to do. I think I was more aware of the real problem than the doctor.'* |
| **Weakened immune system** | *PAUL:' I was more susceptible to picking up colds when I was lighter... It took a long time to recover from these and I would-be put-on antibiotics which obviously affects your ability to train. I would say I don't pick up as many colds now not being a lightweight'* |
| **Musculoskeletal pain and injuries** | *BOB: 'Over the years, I've got some bulging discs in my lower back, I had knee surgery... I basically injured my shoulders from wear and tear and had injections… …lower back flaring up quite a lot so had epidurals for my back… yeah you get niggles all the time'* |

# Chapter VI Investigating the Knowledge, Awareness and Management of RED-S in Lightweight Rowers and Physiotherapists working in Lightweight Rowing in the UK

## 6.1 Results

### 6.1.1 Participant Characteristics

Physiotherapist participants' mean age was 33 (range 23 to 64) years, the year of qualifying as a physiotherapist ranged between 1978 to 2018, and 50% (n=6) identified as female and (n=6) identified as male (table 7). At the time of the interview, two physiotherapists had retired from the profession (retired 12 months and 18 months before the interview), and ten were still working with lightweight rowers. The level of athletes with whom they worked varied from intermediate to international and Olympic level athletes.

***Table 7 Physiotherapist participant characteristics***

| Alias | Age Range | Sex | Year of graduation | Year(s) working with lightweight rowers | Physiotherapy practice |
|---|---|---|---|---|---|
| **AVA** | 29-33 | Female | 2011 | 3 | Current |
| **BEN** | 38-42 | Male | 2014 | 1 | Current |
| **BILL** | 55-58 | Male | 1990 | 15 | Retired (12 months) |
| **EMMA** | 24-27 | Female | 2016 | 4 | Current |
| **FI** | 26-30 | Female | 2015 | 3 | Current |
| **FRANK** | 30-34 | Male | 2008 | 5 | Current |
| **HUGO** | 49-53 | Male | 1996 | 10 | Retired (18 months) |
| **IVY** | 24-27 | Female | 2011 | 3 | Current |
| **JESS** | 22-24 | Female | 2018 | 2 | Current |
| **JOE** | 38-40 | Male | 2002 | 6 | Current |
| **SAM** | 23-25 | Male | 2018 | 2 | Current |
| **TESS** | 60-64 | Female | 1978 | 20 | Current |

### 6.1.2 Summary of results

Five key themes were identified: i) insufficient knowledge of RED-S, ii) inadequate RED-S education, iii) inappropriate management of RED-S, iv) referring responsibility to other health professionals, and v) prioritising performance over health. Each theme is described in the subsequent sections, supported by quotes from physiotherapists and lightweight rowers with each theme, and additional quotes can be found in tables 8 and 9. The themes identified did not differ depending on year of graduation. Suggestions for improving knowledge and management of RED-S in lightweight rowing, from the personal perspective of physiotherapists and lightweight rowers are also provided.

## 6.2 Knowledge

### 6.3 Insufficient knowledge of RED-S

***Physiotherapists***

Only five physiotherapists (42%) knew of RED-S characteristics, and 7 (58%) did not have an awareness of RED-S before the interview. A common misconception was that RED-S only affected women and their menstrual cycle.

> *JESS: 'I think I'd have to know a bit more about it first if someone did come and I suspected it was RED-S and to learn a bit more or educate myself on the best way to help them. But at the minute I haven't seen it enough.'*

> *INTERVIEWER: 'What do you know about RED-S, Relative Energy Deficiency in Sport?'*
> *FRANK: 'I'd actually never heard about it, until I came across your poster for this interview.'*

***Lightweight rowers***

Three lightweight rowers demonstrated an understanding of RED-S by recalling signs and symptoms. Three lightweight rowers had heard of RED-S but could not identify any symptoms nor describe the condition, and 6 had no knowledge/awareness of RED-S.

> *PAUL: 'I have heard of it [RED-S], but I don't know too much about it…no one has ever given a talk on it or anything I must have just come across it before maybe on the internet.'*
>
> *INTERVIEWER: 'Do you know what RED-S is?'*
> *BOB: 'Erm, no can you explain what it is please.'*

## 6.3 Education

### 6.3.1 Inadequate RED-S education

***Physiotherapists***

Physiotherapists could not recall receiving formal education on RED-S during physiotherapy undergraduate degrees. The physiotherapists with knowledge of RED-S had sought information on the internet or came across it through research articles and (n=8, 67%) believed their lack of knowledge might result in long-term health implications.

> *BEN: 'I think the proof is in the pudding really, I got through a physiotherapy degree without knowing about it and it's only because of my own online researching that I know anything.'*
>
> *JOE: 'I came across some literature by mistake almost when I was studying for my PhD... speaking to other professionals RED-S isn't something which anyone really knows about so if we aren't aware of it we can't be educating athletes on it.'*

***Lightweight rowers***

Lightweight rowers expressed dissatisfaction with the lack of RED-S education provided by the medical staff and British Rowing (the national governing body for rowing). Lightweight rowers with an awareness of RED-S sought information from the internet or undergraduate degrees (sports science/sports rehabilitation).

The lack of RED-S education aligns with physiotherapists responses, who did not feel confident in their knowledge to educate athletes. Additionally, lightweight rowers wished they received information about potential long-term impacts of RED-S.

> *ANG: 'No one with a medical qualification who has treated me for some of these symptoms has ever given it the term RED-S or even explained the severity of my symptoms.'*
>
> *PAUL: 'I'm not too sure, no one has ever given a talk on it or anything I must have just come across it before maybe on the internet.'*

## 6.4 Management

### 6.4.1 Inappropriate management of RED-S

***Physiotherapists***

Most physiotherapists felt they lacked the necessary skillsets to discuss and manage RED-S in athletes, and desired further training to equip them better to manage the condition appropriately.

> *BILL: '… if they brought it up with me. I think an issue I have is approaching things with people when they don't bring it up. I will just speak to the psychologist if I think they have an issue to try and prompt them to talk to them. I guess I could do with more training in this area.'*

> *EMMA: 'I try to make them aware where I can, but I don't have enough knowledge on the exact science so wouldn't actually know how to advise them on the long-term implications.'*

***Lightweight rowers***

Every lightweight rower suffered from at least one RED-S symptom; however, only one individual felt that they received appropriate and useful management.

> *MIA: 'I think a lot of people with different opinions give you really strange advice which doesn't help when you're 18 and its usually just from their own experience and there's no science to back up what they're saying.'*

> *AMY: 'I didn't know what my pain was because I was being diagnosed with different things. It turned out that I actually had fractured it [rib]... I raced [specific race] with a fractured rib...I have osteopenia... my hips are the worst affected... no I didn't ever really get any treatment.'*

### 6.4.1 Referring responsibility to other health professionals

***Physiotherapists***

Most physiotherapists did not know how to appropriately manage RED-S and would refer to other HCPs. Two physiotherapists believed it was not their responsibility to treat RED-S and believed other HCPs were better qualified to manage the condition.

> *FRANK: 'Honestly, I would just refer onto the GP as I don't feel I have the knowledge to know what to do in this situation.'*

> *SAM: 'If ever I feel out of my depth, I will look things up or refer onto someone in a specialist field, usually athletes are wanting to find every inch which can make them faster so they're willing to travel to specialists... I don't think as healthcare professionals we know enough about this area as we are always referring on to someone who knows more.'*

***Lightweight rowers***

The lightweight rowers expressed concern with how their symptoms of RED-S were mis-managed by medical staff.

> *MARY: 'I still had issues with my period, so I was sent to the doctor after I told (Physio) who didn't really know how to help... I told the doctor about it and they were just like 'oh don't worry that's normal for athletes'.'*

> *AMY: 'I got that diagnosis of Osteopenia after being seen by lots of different professionals, I was never told how to prevent this or prevent your bones weakening when you're dieting, just eat loads of yoghurt and have loads of mushrooms kind of thing.'*

## 6.5 Athlete well-being

### 6.5.1 Prioritising performance over health

***Physiotherapists***

Seven (58%) physiotherapists were aware of the extreme weight loss tactics. Some felt uncomfortable discussing potential health impacts of weight loss with athletes, as it is deeply ingrained into lightweight rowing culture. Two physiotherapists believed educating lightweight rowers on long-term health implications of weight loss was not their role and may cause tension between athlete and coach, with most coaches prioritising performance over health.

> *TESS: 'It's so traditional, the coaching staff in charge of lightweights were lightweights themselves once… .I would say they weren't particularly looked after at all… Even if we didn't think it was particularly safe or healthy… .the biggest obstacle is obviously a coach who is not sympathetic towards the athlete.'*

> *BEN: 'There needs to be improved support for the athletes too. The sad priority for most of the rowers and the coaches is that they perform on race day and that means making weight, how they get to weight is left up to the athletes, which often means compromising on minerals and vitamins causing lots to get ill.'*

***Lightweight rowers***

The lightweight rowers also believed their coaches did not care about the health consequences of their weight-loss practices and were focussed on optimising performance.

> *TAL: 'I went to this talk on RED-S, my coach came up to me afterwards and was like that was a load of bullshit, they were like you don't have RED-S. So, I was quite angry because I know for sure I do and women in the club do.'*

*ANG: '..., I tended to yo-yo like 85% of the time with dieting which didn't help my training performance as I would just have like no energy during the sessions and my coach would comment on how awful I looked which I know was due to how little I was eating. Trying to lose the weight, I was doing a lot more sweaty exercise to help lose the weight, whilst feeling awful at the same time but building up to the big competitions we were doing like 3 sessions a day and we would continue to build on this with intensity and length of pieces before tapering just before the race day. It did definitely make me more ill and took me ages to recover....'*

***Table 8 Additional supporting quotes for each theme***

| Table | Physiotherapists | Lightweight Rowers |
|---|---|---|
| **Insufficient knowledge of RED-S** | INTERVIEWER: 'Have you ever heard of the term Relative Energy Deficiency in Sport?<br>EMMA: No, but when I looked it up, after contacting you for your study, I saw it was like the female athlete triad and I have heard of that.' | MIA: 'I think my mum actually read an article on RED-S and I read a book by a doctor called 'Girls on the Edge' just about teenage girls in high stressed environments getting addicted to sport and eating disorders...not from rowing coaches or anyone.' |
| **Inadequate RED-S education** | SAM: 'It was by mistake; I was researching for a module when I was at uni and came across (name) who had written a blog on her symptoms and how it had impacted her performance... I have since done a bit more self-research, but never had anything taught to me.' | INTERVIEWER: 'How did you hear about RED-S?'<br>MARY: 'Mentioned briefly in my degree but it's mainly from researching myself.'<br>INTERVIEWER: 'Has any healthcare professional discussed RED-S symptoms with you?'<br>MARY: 'No, none of them ever really like to talk negatively to or about athletes.' |

| | | |
|---|---|---|
| **Inappropriate management of RED-S** | INTERVIEWER: 'What is your opinion on educating athletes on the adverse side effects of the sport?'<br>HUGO: 'It should probably be done, but I have no idea on what they are and wouldn't really know how to handle the situation now, with athletes who seem a lot younger now.' | MIA: ... 'I didn't have the best experience with coaches or physios, especially when I went to uni...I think really it came down to no one really knowing how to treat me. I got a bulging disc in my back and they were like oh it's obviously because your upper body got so stripped out when you were a lightweight, and you aren't supporting your muscles but that's like a critique of what you look like rather than what is actually anatomically going on with your body... quite a lot of people were having opinions on my body.' |
| **Referring responsibility to other health care professionals** | TESS: "…It's not always our job to do it directly, but we can signpost appropriately and flag it up. I would always refer if there were reoccurring stress responses and suspicious back pain. We are just a cog in the system." | GRACE: "I got sent to the doctors as the physio didn't know what to do with me and their [doctor] response was like, 'why?' I'd sort of diagnosed myself after like googling and I was like I do too much exercise and don't eat enough and they were just like 'why' and you know when someone looks at you and just don't understand you, because they were like 'you just need to do less exercise and eat more.' So, like I didn't really take her advice properly, or like as much as I should have.' |
| **Prioritising performance over health** | FI: "They literally haven't eaten properly for months on end, now I'm not blaming the, they don't know what else to do...they also use the crazy tactics to get down to weight and will prioritise making weight so they can race over anything | TAL: 'There were times when like none of us were eating and we really should have been eating...we were scared of not making weight and that meant if you saw your teammate really struggling or not eating you were like 'Oh I have to do the |

| | | |
|---|---|---|
| | else so above their health needs both physically and psychologically.' | same'.... my weight fluctuation was ridiculous... I really struggled on food and my relationship with food, so I said that to him [coach]. And he kind of didn't acknowledge it, so he wasn't really the most supportive with that at all...' |

## 6.6 Raising awareness

### 6.6.1 Suggestions for improving knowledge and management of RED-S in lightweight rowing

All 24 participants provided suggestions for improving the dissemination of knowledge to increase awareness of RED-S amongst the HCP, coaches, and lightweight rowers.

***Physiotherapists***

Physiotherapists believed certified RED-S professional development courses are needed and should be thoroughly addressed in undergraduate physiotherapy curriculum. Physiotherapists wanted sufficient training and knowledge to identify and manage RED-S appropriately/effectively and to inform athletes about potential long-term implications.

> *BEN: 'I got through a physiotherapy degree without knowing about it [RED-S] … only because of my own online researching that I know anything, so I think there needs to be a section on it within the course …there also should be a focus on the long-term implications…'*

> *EMMA: 'Firstly, needs to be in undergrad talks, should also be on the weekend type courses... All athletes get magazines every month...could be articles on [RED-S] symptoms...'*

***Lightweight rowers***

Lightweight rowers suggested ways of improving knowledge of RED-S including presentations, articles in sporting magazines and educational handbooks on signs/symptoms of RED-S. Safe/legal advice on weight loss, long-term risks of dieting and coping strategies physically and psychologically. They also suggest changing racing regulations; increasing the 2-hour weigh-in time before racing and reducing the requirement for athletes to lose through winter-summer competitions (men 75kg-70kg, women 62kg-57kg).

> *PIP: 'There needs to be a greater structure and maybe more guidance because I remember I used to Google like 'guidelines for lightweights' and 'what to eat'. British Rowing should definitely look into producing some sort of handbook for athletes… it would be good for there to be an understanding of doctors and physios… to take time off [for injury] maybe not the best thing… they need to be taught how to manage athletes.'*

> *BOB: 'I think they should talk to you about making sure you have some sort of plan, too many people have got no idea what they want to do after this next Olympics and if their health has been compromised during lightweight it could inhibit certain things they do once retired. I'd have liked more advice on getting down to weight and a bit more advice on preventing illness.'*

***Table 9 Additional quotes: suggestions for improving knowledge and management of RED-S in lightweight rowing***

| Theme | Physiotherapist | Lightweight Rowers |
|---|---|---|
| **Improving knowledge and management of RED-S** | TESS: 'Obviously, I think it should be part of your training with any sports if you're doing any sports at all, especially those that have a specific weight tolerance. Training wise it should be there all the way from the beginning, even if you're not dealing with athletes, as obviously anyone with potential osteoporosis or anything like that doesn't necessarily have to be a sports person.' | ANG: '...raising awareness and making sure the head coaches in the institutions and those working with athletes know what it [RED-S] is and are comfortable talking about it and diagnosing...obviously you can't realistically reach every single lightweight all the time but you can educate the people that are going to be mentoring then maybe setting up a group... so people who have been through lightweight rowing can give advice and as RED-S is a scary thing but you kind of feel better about it talking to people you respect and discussing any worries.' |

# Chapter VII Discussion

## 7.1 Discussing Results

### 7.1.1 Summary of findings

In this study, lightweight rowers did not meet their energy needs due to high EE and restricted calorie intake, which negatively impacted their psychosocial and physical health. These findings are supported by previous research highlighting a need for effective strategies to prevent and manage RED-S whilst improving education and support for athletes. These results suggest a potential revision of weigh-in regulations to protect lightweight rowers' welfare should be considered. The primary researcher (LG) wanted to have representative data for men and women. However, participation relied on volunteers, restricting the research to those who responded; 8 women and 4 males. However, themes identified were similar amongst both the men and women, meaning the data did reach a point of saturation. The main difference noted were men felt less able to speak out about the psychological impact 'feeling skinny and weak' was having on their mental health, aligning with the stigma against men's mental health.

The first aim was '*to investigate the physical and psychosocial impact of RED-S from the personal perspective of lightweight rowers in the UK'*, the key themes identified to support the first aim were calorie restriction with a high energy expenditure resulted in physical implications of disrupted sleep, menstrual dysfunction, impaired recovery, decreased performance, fatigue, bowel disruption, musculoskeletal pain and injuries and weakened immune system. The psychological implications identified were reduced social interaction, low mood, guilt and anxiety around food, difficulty maintaining relationships, poor concentration, poor emotional regulation, disordered eating and negative body image.

The second aim was '*to investigate the knowledge, awareness and management of RED-S in lightweight rowers and Physiotherapists working in lightweight rowing in the UK*', the key themes identified to support this aim were, insufficient understanding of RED-S, inadequate RED-S education, inappropriate management of RED-S and inappropriate referrals to other HCP.

## 7.2 Physical implications of RED-S

### 7.2.1 Low Energy Availability

All lightweight rowers recruited suffered from at least one symptom of RED-S due to low energy availability. One of the most common symptoms among females was menstrual dysfunction, whilst other common symptoms included disrupted bowels, muscle loss, an inability to recover from sessions or to rest after training. These symptoms can be exacerbated if an athlete has high EE and low-calorie input (Manore, 2015). Energy intake must align with EE to maintain adequate physiological function, growth/repair of tissue and prevent illness (Manore, 2015). Lightweight rowers in this study used weight-loss tactics and experienced a 'yo-yo' effect of weight fluctuation.

### 7.2.2 Weight loss

All lightweight rowers within this thesis reported weight-loss tactics including dieting and increasing exercise in the weeks leading up to an event. As well as through increasing sweat loss so there is less water retention by dehydrating themselves the morning of an event before weighing in, e.g. by using hot baths, saunas, laxatives, and light exercise whilst wearing layers of clothing, some reported using bin bags during warm-up routines. A correlation has been found between weight-restricted/leanness sports and athletes who

suffer from RED-S, due to their extreme weight loss methods and rapid weight fluctuation, which can be detrimental to health and performance (Sungot-Borgen et al., 2011). Sungot-Borgen et al., (2011) suggested improving education so signs and symptoms can be recognised among athletes and a potential revision of weigh-in regulations. Hence, athletes have sufficient time to rehydrate and refuel before participating in sport. The findings of this study support the suggestions made by participants within this thesis that more effective strategies are needed to prevent RED-S and support athletes, as well as potentially revising the weigh-in regulations to protect athletes.

### 7.2.3 Musculoskeletal pain and Injuries

The common injuries lightweight rowers reported in this thesis, coincided with those reported by Thornton et al. (2016) in a review of injured rowers. These injuries were lower back pain, including disc herniation, facet joint strain, vertebral fractures, rib stress fractures and knee, shoulder, hip, and wrist pain. These injuries can significantly impact an athlete's performance both in training and in competition. A study from 2012 investigated the aetiology of damages in all rowers (lightweight and heavyweight) and found they were primarily caused by overuse due to the volume of training causing stress on the body (Hosea et al., 2012). As this study incorporates all rowers, it supports the findings within this thesis of the physical implications on a lightweight rowers body. From the literature reported on weight-dependent sports and their BMD, it can be inferred that lightweight rowers who diet and suffer from symptoms of RED-S are at a greater risk of the musculoskeletal injuries including stress fractures (Hosea et al., (2012) and Thornton et al., (2016)).

### 7.2.4 Disrupted sleep

Lightweight rowers in this study described difficulties sleeping due to hunger, being over-tired and not having enough time to scheduled early training sessions. This can increase the risk of overtraining syndrome and under-recovery (Mountjoy et al., 2018). Sleep has numerous vital physical and psychological functions for athletes and is one of the most crucial contributions to successful athletic performance (Halson, 2014). Sleep can increase vigour, learning ability and mood (Halson, 2014). If an athlete's sleep is negatively impacted due to hunger, the implications of under-recovery and poor sleep could increase. Insufficient sleep can negatively impact athlete's performance, in and out of competition, due to fatigue thus reducing metabolism, endocrine function, cognition, immunity, pain perception and increasing the risk of inflammation (Halson, 2014). This supports the findings from this thesis that restricting calorie intake and increasing energy expenditure can lead to disrupted sleep.

### 7.2.5 Decreased Performance

Many of the lightweight rowers within this thesis discussed how their negative experiences, such as extreme weight loss and dieting, impacted their mood and participation in rowing. A survey of 293 students about recollections from participating in sport and physical activity found that students who had negative memories/experiences during sport and physical activities were more likely to have decreased performance in sport and cease activity participation later in life due to these experiences (Cardinal et al., 2013). The limitation of this study is it did not discuss the sports the students participated in nor what negative experiences they had. However, it did highlight the importance of positive sporting experiences to increase longevity in sport (Cardinal et al., 2013). Dieting can affect energy levels, performance and mood (Strasser et al., 2015). If young lightweight rowers have

increased negative experiences in sport due to gruelling weighing-in tactics, it could reduce their likelihood of continuing with the sport and may have a detrimental effect on their current performance in sport as they may learn to resent the physical activity.

## 7.3 Psychosocial implications of RED-S

### 7.3.1 Relationship with food

Individuals in this study believed lightweight rowing negatively affected their relationship with food, often persisting once retired from the sport. Daily calorie counting can increase the risk of developing DE (DeFeciani, 2015). Disordered eating among lightweight rowers is not a new phenomenon, and a higher prevalence of DE has been reported among collegiate lightweight rowers when compared with the heavyweight category (Gapin et al., 2013). Furthermore, in a study of n=103 elite heavyweight and lightweight rowers, the lightweights were significantly more likely to have DE, depression, confusion, and tension (Warren, 1999). Although, this study was performed over 20 years ago the results are still relevant and supported by updated literature such as Meheler et al., (2015). Having DE negatively impacted upon health, adversely affecting gastrointestinal, endocrine, hematologic, neurologic, bone metabolism, pulmonary and cardiac function (Mehler et al., 2015), which align with the findings in this study. The above literature emphasises the importance of improving knowledge and education of RED-S to reduce the severe associated health consequences.

### 7.3.2 Poor concentration

The lightweight rowers from this study reported having decreased concentration due to hunger and stress of weighing-in correctly, which had negative implications on their performance. Sport can increase engagement (Ghildiyal, 2015) as most sports require a

high level of focus to succeed. However, hunger can act as a distraction and reduce concentration, as the athlete is focused on their hunger levels rather than their sport (Schwartzbard, 2020). Therefore, supporting the results of lightweight rowers reporting that their hunger affected their ability to concentrate. This emphasises the importance of proper nutritional education for athletes in weight-restricted and leanness sports to ensure athletes know how to 'make weight' whilst maintaining appropriate calorie intake and energy availability.

### 7.3.3 Disordered eating and negative body image

All physiotherapists in this study commented on the many pressures that lightweight athletes faced reaching their target weight and suggested these could increase the risk of DE, a symptom of RED-S. The first study to examine DE prevalence in both male and female athletes was in 2003, n=263 Australian elite athletes from a variety of sports and n=263 non-athletes were interviewed and completed several self-report questionnaires (Bryne et al., 2003). The results highlighted sports emphasising lean body shape or low body weight had a significantly higher prevalence of DE than any other sports (Byrne et al., 2003). This supports the results found within this study as all lightweight rowers had forms of DE and ED, which resulted in negative body image and low self-esteem, which could affect an athlete's mental health in the long-term (Mountjoy et al., 2018). Therefore, supporting the suggestions made by physiotherapists within this thesis that the pressures of 'making weight' can contribute to increased risks of DE within lightweight rowers.

The dieting process and pressure of being a lean lightweight rower impacted how some participants perceived their body shape, with one rower reporting they had 'body dysmorphia'. Studies as early as 1990 have been reporting on lightweight rowers eating

behaviours and how this has impacted on their mood and body shape. A study by Terry et al. (1999) investigated eating behaviours in lightweight and heavyweight male and female rowers who competed in the 1996 National and World championships (Lightweight: n=31 male, n=19 female and heavyweight: n=25 females, n=28 males). The Body Shape Questionnaire (BSQ) and the Eating Attitude Test (EAT) demonstrated that elite lightweight rowers were at a higher risk of having an altered mood due to dieting, which can increase their risk of an ED resulting in body dysmorphia. This study also concluded that if measures are taken to assess athlete's mood, this may help to identify athletes at risk of eating disorders and appropriate support and treatment can be provided (Terry et al., 1999). Whilst this study was performed over 20 years ago, the findings are still relevant as the lightweight rowers from within this thesis spoke of how their mood impacted their diet and ultimately affected how they perceived their body. As this study was performed over 20 years ago, it suggests there has been little improvement in RED-S education.

### 7.3.4 Reduced social interaction and difficulty maintaining relationships

Lightweight rowers from this thesis described adverse effects on their social life and personal relationships due to lightweight rowing, but accepted it is *''just a sacrifice you have to make.''*. Such beliefs may reduce athlete's communication with coaches and the sports medicine team about psychosocial health, inhibiting adequate education and management. A 2009 study assessed n=87 elite-level athletes who were either in romantic, marital, or heterosexual relationships. This study found athletic performance can be negatively affected by the athlete's personal relationships (Jowett et al., 2009). Therefore, indicating the reduced social interaction can increase the risk of difficulties in maintaining relationship, which can negatively impact their athletic performance.

## 7.4 Knowledge

### 7.4.1 Poor knowledge of RED-S

Less than half of the physiotherapists from this thesis correctly described the symptoms of RED-S. Although RED-S is a relatively new syndrome compared to F.A.T., evidence suggests knowledge of F.A.T. was also poor amongst the HCP's (Keay, 2018). In 2018, it was reported that less than 50% of physiotherapists, coaches, and clinicians correctly identified components of F.A.T (Keay, 2018). In 2012 the prevention of F.A.T. was investigated in Australia, of the n=919 females (frequent exercisers) who completed the survey only 10% correctly named the 3 F.A.T components. Additionally, 45% of frequent female exercisers believed that they did not have amenorrhea but had a past medical history of menstrual dysfunction and stress fractures. This study found that participation in leanness sports, a past medical history of stress fractures and amenorrhea were associated with inappropriate treatment (Miller et al., 2012). These results suggest that more educational programmes are needed for frequent exercisers. Therefore supporting the suggestions made by the 24 participants from this thesis who suggested more education is necessary for athletes to recognise the symptoms and for HCP's to be aware of screening tools to increase early detection and appropriate management pathways.

## 7.5 Management

### 7.5.1 Poor management of RED-S and prioritising performance over health

The results from this study suggest that physiotherapists and other HCP may be poorly managing lightweight rowers with RED-S in the UK. Appropriate management of RED-S involves re-balancing an athlete's energy availability rather than using pharmacological

interventions such as the oral contraceptive pill which merely masks symptoms (Mountjoy et al., 2015). Additionally, use of the RED-S Clinical Assessment Tool (CAT) Assessment Model is recommended to inform the medical management of athletes (Mountjoy et al., 2015) and the RED-S Return to Play (RTP) step-by-step model is recommended for use following appropriate treatment (Mountjoy et al., 2015). Whilst it has been reported that the RED-S CAT is 'widely used in clinical practice' (Mountjoy et al., 2015) it has not been validated or assessed for efficacy or feasibility for use in athletes.

Physiotherapists described the challenge of juggling pressure from athletes and coaches to make weight and perform, with the responsibility of a physiotherapist to put the health and welfare of the athlete first. Additionally, participants described a culture of prioritising performance over athlete health, which can be considered a form of physical and psychological abuse (Mountjoy et al., 2020) and a barrier to effective prevention and management of RED-S. Implementing RED-S management and return to play guidelines may provide physiotherapists with greater confidence to effectively manage RED-S, and to ensure that the athlete's health and welfare is prioritised.

## 7.6 Management and Knowledge

### 7.6.1 Poor knowledge leading to poor management

Poor understanding of RED-S may lead to underdiagnosis and incorrect administration of an athlete. Inappropriate management of athletes could result in long-term health problems, such as osteoporosis from LBMD and systemic illnesses as a result of DE and malnutrition (Boutari et al., 2020). Physiotherapists and lightweight rowers within this thesis identified a lack of education as the key reason for their knowledge gaps. The limited evidence available suggests education should be specific to athletes, coaches, parents, and any HCP working

with the sports team (Mountjoy et al., 2015). Based on physiotherapists' recommendations, RED-S education should be incorporated into physiotherapy undergraduate curriculums and further training offered through professional development courses. More robust RED-S education and training for physiotherapists in the UK should be prioritised since this may have significant health implications for athletes (Mountjoy et al., 2018).

Physiotherapists within this study described feeling ill-equipped to manage RED-S in athletes, and often referred them to other HCPs whom they believed would provide better quality care. However, a recent study in 2020 found no significant difference between physicians and allied health providers knowledge of RED-S (Tenforde et al., 2020). Whilst 76% of health professionals were aware of F.A.T., only 29% were aware of RED-S. Additionally, 33% felt comfortable treating F.A.T., but only 13% felt comfortable treating RED-S (Tenforde et al., 2020). This aligns with the experiences of lightweight rowers, where they described being referred to a range of HCPs and being dissatisfied with the care received. Formal education and training for physiotherapists may empower them to take responsibility for diagnosing and managing RED-S in athletes. When a referral to specialists is appropriate, physiotherapists should remain as a member of the multidisciplinary team and communicate with other health care providers. As a profession, physiotherapists are well placed to detect RED-S early and to facilitate effective management of the condition alongside members of a multi-disciplinary team. Potential strategies to improve detection and management of RED-S in lightweight rowers include mandatory physical and psychological health screening examinations for athletes, RED-S educational presentations and resources for athletes and coaches, and formal training for HCP. Additionally, consideration should be given to reconsidering the 2-hour time allowance between

weighing-in and competition and increasing the weight limits to protect the health and wellbeing of lightweight rowers.

## 7.7 Strengths and potential limitations

The interviewer's personal experience with lightweight rowing, RED-S, and as a qualified physiotherapist enabled a strong rapport with participants. The use of qualitative research allows for an in-depth perspective from participants so their quotes can be used to add meaning to the data. This may have contributed to the in-depth responses provided by participants. Despite this, it is possible that participants may not have disclosed all information due to the sensitivity of the subject. Two physiotherapists were retired at the time of interview and relied upon their ability to recall events from 12-18 months previously, increasing the risk of recall bias. Additionally, former lightweight rowers reflected upon their past experiences, potentially resulting in recall bias. However, involving former lightweight rowers provided essential insights into the long-term impacts of RED-S.

The level of lightweight rowing experience ranged from the grass-root level, competing at local competitions to elite, and Olympics athletes, making the qualitative data from the results more transferable and credible (Polit et al., 2020) to the UK population of lightweight rowers. The graduation date of the physiotherapists spans over 40 years, and the age range was between 22-64 years. This provides transferable qualitative data (Polit et al., 2020) of registered physiotherapists working with lightweight rowers in the UK.

A strength of this study was the inclusion of a diverse group of physiotherapists, with a range of clinical experience, who had worked with lightweight rowers at varying competition levels, and a wide range of experienced lightweight rowers, both male and female, making the

results more generalisable. Similarly, we interviewed former rowers who recalled their experiences retrospectively, although their responses may have been subject to recall error, the inclusion of these individuals provided a unique viewpoint on the long-term implications of RED-S. Another strength of this study was the ability to draw upon both experiences of both physiotherapists and lightweight rowers, providing deeper insights into RED-S in lightweight rowers.

Conducting telephone interviews rather than face-to-face interviews can produce more honest responses as participants are without fear of judgement as some people find it beneficial not seeing the person to whom they are talking about sensitive issues (Fowler et al., 2002). Telephone interviews reduce participant travel, which is time and cost effective, as it can be performed at a time convenient to the participant as well as being a safe form of interviewing particularly through the year of 2020 with the Covid-19 restrictions. However, it does rely on participants to have strong signal for the duration of the telephone call. Participants body language and behaviour are unable to be observed and it does not allow for visual aids to assist the interview process. Using social media as a recruiting platform relied on participants having a social media account and could potentially limit the sample size. Nevertheless, social media provided a practical and efficient way of recruiting participants across the UK.

## 7.8 Recommendations for future research

This study did not look at the knowledge, and education parents have. However, the data identified this as a future potential in research. This study was limited to only physiotherapists, and lightweight rowers, future research could explore other high-risk sports and medical staff.

Most research on RED-S is currently focused on athletes, future research explore prevalence of RED-S qualitative and quantitatively in non-athletes and how they are affected physically, psychologically and psychosocially as anyone can suffer from RED-S symptoms if they have high EE and low-calorie input, especially as there is an ever-growing pressure from social media to have the desired body shape.

## 7.9 Clinical Recommendations

Based on the results of this study and the existing literature, RED-S and its symptoms should be incorporated into physiotherapy undergraduate degrees around the world. Improving understanding of clinicians will increase the likelihood of athletes receiving early detection and timely intervention. For clinicians who have already graduated and are working with athletes, refresher knowledge and continual professional development (CPD) courses should be made available, so professionals feel confident in how to recognise symptoms and manage them appropriately. The author of this thesis is currently working on raising awareness of RED-S amongst children and adolescents through education as part of the National Personal, Social, Health and Economic (PSHE) Curriculum within UK schools which could have positive future health implications.

The findings highlight the need for effective strategies to prevent and manage RED-S in athletes. The health impacts of RED-S support the need for revision of weight restrictions and weighing in regulations to protect lightweight athletes' welfare. Raising awareness of RED-S and educating HCP's, coaches, and athletes of the severe health consequences of RED-S should be a priority within lightweight rowing and other weight-dependent sports.

# Chapter VIII
# Conclusion

## 7.1 Conclusion

Restricting calorie intake whilst increasing energy expenditure to ‘make weight’ has significant physical and psychosocial implications for lightweight rowers. The physical impacts of RED-S included disrupted sleep, fatigue, decreased performance, impaired recovery, bowel disruption, menstrual dysfunction, weakened immune system, musculoskeletal pain and injuries. The psychosocial impacts included low mood, poor emotional regulation, reduced social interaction, difficulty maintaining relationships, low concentration, guilt/anxiety around food, disordered eating and negative body image. This study stresses the importance of effective strategies to prevent and manage RED-S and consequently, improve the physical and psychosocial health of lightweight rowers.

There was a significant lack of awareness and knowledge of RED-S amongst physiotherapists and lightweight rowers in this study, which was related to inappropriate management of RED-S. Physiotherapists frequently referred athletes with RED-S to other health professionals, and lightweight rowers were dissatisfied with the lack of education and inadequate management they received. The thesis findings suggest that formal education on RED-S is needed for physiotherapists and strategies should be developed to improve awareness of RED-S in lightweight rowers and coaching staff.

# Appendices

## Appendix 1- Ethics Approval

**MEDICAL SCIENCES INTERDIVISIONAL RESEARCH ETHICS COMMITTEE**
Research Services, University of Oxford, Wellington Square, Oxford, OX1 2JD
Tel: +44(0)1865 616577 Fax: +44(0)1865 280467
ethics@medsci.ox.ac.uk

**CONFIDENTIAL**

Ref: R67265/RE001

Lucy Gillbanks
Botnar Research Centre
NDORMS
University of Oxford
Windmill Road
Oxford

30th January 2020

Dear Lucy,

**Research Ethics Approval - CUREC 1**

**Study title: Lightweight rowers' and physiotherapists' perspectives of managing and living with Relative Energy Deficiency in Sport**

**Short title: Physiotherapists' and athletes' experiences with RED-S in lightweight rowing**

The above application has been considered on behalf of the Medical Sciences Interdivisional Research Ethics Committee (IDREC) in accordance with the procedures laid down by the University for Ethical Approval of all research involving human participants.

I am pleased to inform you that, on the basis of the information provided to the IDREC, the proposed research has been judged as meeting appropriate ethical standards, and approval has been granted for a period of **1 year**, commencing on **1st February 2020**. The reference number for this study is **R67265/RE001**.

This is **subject to:**

a) **the PI agreeing to comply with the requirements for administering any tests or questionnaires and, if in doubt, to contact the publisher of those tests or questionnaires**

b) **the PI ensuring that, where new research staff are engaged, they are suitably qualified by training and/or experience.**

I would like to remind you that your study may be selected for review by the MS IDREC for the purposes of monitoring and/or audit.

**Amendments**

Should there be any subsequent changes to the study, you should submit details to the MS IDREC for consideration and approval. Details of changes must be listed on an amendment form.

Please do not hesitate to contact me if you have any queries.

Yours Sincerely

H. Barnby-Porritt

Dr. Helen Barnby-Porritt
Research Ethics Manager, Medical Sciences

## Appendix 2- Participant Information Sheet

Department Contact Details: Botnar Research Centre
Windmill Road, Oxford, OX3 7LD, UK
Tel: 01865 227 374
brc.reception@ndorms.ox.ac.uk

**Primary Investigator:** Lucy Jane Gillbanks, MSc Musculoskeletal Science (Res) student.
Email: lucy.gillbanks@lmh.ox.ac.uk
Contact number: 07958935661

**Supervisor:** Dr Stephanie Filbay B. Phty (Hons), PhD. Senior research associate in orthopaedics, rheumatology and muscloskeletal sciences. University of Oxford.
Email: stephanie.filbay@ndorms.ox.ac.uk

**Supervisor:** Professor Nigel Arden MBBS, FRCP, MSc, MD. Professor in rheumatic diseases, , University of Oxford.
Email: nigel.arden@ndorms.ox.ac.uk

**Title:** ' Relative Energy Deficiency in Sport (RED-S) in lightweight rowing: investigating athlete and physiotherapists' perspectives

**Name of Researcher**: Lucy Jane Gillbanks

Participation Information Sheet
I would like to invite you to participate in my research study for my MSc at the University of Oxford. Before deciding whether you would like to participate, the following information will help to explain what the research is about and what you will be required to do.

1. What is the purpose of this research?

The purpose of this study is to gain an understanding of the current knowledge and awareness of RED-S (Relative Energy Deficiency in Sport) amongst Physiotherapists who

work with lightweight rowers in the UK, and how they would manage the condition. It is also to gain an understanding of how RED-S can affect a rower's life daily.

2. Why have I been invited?

You have been invited to participate because you are over the age of 18 years old and are either a current/ ex lightweight rower in the UK, or you are a Physiotherapist in the UK, who works with lightweight rowers. We are inviting approximately 10 other participants like you to take part.

3. Do I have to take part?

It is entirely up to you whether you decide to take part. You will be asked at the beginning of the interview if you consent to the questions being asked and for your data to be included in the study. You can withdraw at any point of the telephone interview without explanation. Once the telephone interview is over, you can withdraw from the study and your data will be deleted, up to 2-week's after the interview. After this time, your data will be de-identified and used for research purposes.

4. What will happen to me if I take part?

You will be required to participate in a one on one telephone interview which will take around 30-60 minutes, at a time that is convenient for you. This will involve having an open discussion about the impacts RED-S has on your daily life if you are a rower, and if you are a Physiotherapist participant this will be a discussion of your knowledge and awareness and the management option you would use. The interviews will be audio-recorded, so the researcher can transcribe the audio into text after the interview. At this stage, your name will be replaced with a pseudonym, so the text is not identifiable. Any publications from this work will not contain any identifiable information. If you do not want to be audio-recorded, we ask that you do not take part in the study.

5. Expenses and inconvenience allowance?

Participates will not be paid to participate in this study, nor will they be required to travel anywhere to participate in the study.

6. What are the possible disadvantages and risks of taking part?

The topic of questions 'Relative Energy Deficiency in Sport' can be an emotive topic for some people. If you feel you are affected by any of the questions within the survey and seek advice, please speak to your coach or GP. After you have completed the interview, if you wish to know more information, please indicate this to the researcher and website links will be provided, which you can follow in order to gain a better understanding of the Relative Energy Deficiency in Sport.

7. What are the possible benefits of taking part?

The data generated from this study will inform the future development of education and awareness raising regarding RED-S amongst both lightweight rowers and Physiotherapists who care for them. Whilst this might not benefit you directly, it will have value for future athletes and healthcare professionals.

8. What happens when the research study stops?

The information you provide as part of the study is the research data. Any research data which is identifiable to a reader such as your name and your audio-recording will be stored on The University of Oxford internal server in the form of an encrypted, password protected document (and in a locked filing cabinet at The University of Oxford). This information will be stored separately from the interview transcripts which will be anonymised, and only accessed by The University of Oxford researchers working on this project. All research data will be kept securely for a maximum of 53 years. This is compliant with legal obligations and the General Data Protection Regulations (GDPR). After this time, your data will be disposed of securely. During this time only members of the research team will have access to your data.

Personal/ Sensitive data

As this data is concerning your health, it will be stored confidentially using an encrypted, password protected document (and in a locked filling cabinet at The University of Oxford). The information being recorded is personal beliefs and experiences with RED-S, pseudonyms will be used where necessary and there will be no use of names throughout the transcribing of the audio-recordings. The data will be stored for a maximum of 3 years after completion of the research. The data will not be used in future research. Pseudonym's

will be used for any identifiable data when the audio-recordings are transcribed and used in the write up of the results to protect you identify and
personal data. When you consent to participating in the study, this will be audio-recorded and recorded on a consent form by the researcher. Audio-recordings will be destroyed after they have been transcribed.

9. What if there is a problem?

If you have a concern about any aspect of this study, you should relay this to the interviewer who will do their best to answer your questions. Please contact; Lucy Jane Gillbanks: Physiotherapist, Postgraduate student at The University of Oxford. Email lucy.gillbanks@lmh.ox.ac.uk. The researcher should acknowledge your concern within 10 working days and give you an indication of how they intend to deal with it.

**Dr Stephanie Filbay:** Postdoctoral Research Fellow at Nuffield Department of Orthopaedics, Rheumatology and Musculoskeletal Sciences Botnar Research Centre, Windmill Road, Oxford, UK, OX3 7LD. Email: stephanie.filbay@ndorms.ox.ac.uk

If you remain unhappy or wish to make a formal complaint, please contact the relevant chair of the Research Ethics Committee at the University of Oxford who will seek to resolve the matter in a reasonable and professional manner. Chair, Medical Sciences Inter-Divisional Research Ethics Committee, Email: ethics@medsci.ox.ac.uk Address: Research Services, University of Oxford, Wellington Square, Oxford OX1 2JD

10. Who is funding the research?

There is no external research funding for this research study.

11. Will my taking part be kept confidential?

We will follow ethical and legal practice and all information about you will be handled in confidence

If you join this study, the data collected for the study will be looked at by authorised persons from the University of Oxford who are organising the research. They may also be looked at by authorised people to check the study being carried out, is being completed correctly. All will have a duty of confidentiality to you as a research participant and we will do our best to meet this duty.

All information which is collected about you during the research will be kept strictly confidential, stored in a secure office and on a password protected database. You will not be required to provide your name or address for this study.

12. What will happen if I don't want to carry on with the study?

Your participation is voluntary, and you are free to withdraw at any time, even after completion of the interview. You may withdraw, without giving any reasons, and without your legal rights being affected. If you withdraw, the information collected so far can be erased. If you decide to withdraw within the 2-week period after the interview, all data withdrawal cannot be guaranteed as it will be anonymous and therefore not identifiable to delete.

13. What will happen to my results/data of the study?

The data collected will be produced as a postgraduate Thesis in August 2020. This research may be published in a medical journal.

14. Who is organising and funding the research?

The research is being organised by The University of oxford, under the supervision of Dr Stephanie Filbay and Professor Nigel Arden at the Nuffield Department of Orthopaedics Rheumatology and Musculoskeletal Sciences at the Botnar Research Centre Old Rd, Oxford OX3 7LD.

15. Who has reviewed the study?

This study has been reviewed by, and received ethics clearance through, the University of Oxford Central University Research Ethics Committee (Reference number: R67265/RE001). All research in the University of Oxford is looked at by an independent group of people called a Research Ethics Committee, to protect you interests.

16. Data Protection

The University of Oxford is the data controller with respect to your personal data, and as such will determine how your personal data is used in the study.

The University will process your personal data for the purpose of the research outlined above. Research is a task that we perform in the public interest.

If you wish to seek further information about your rights with respect to your personal data it is available from the following link: http://www.admin.ox.ac.uk/councilsec/compliance/gdpr/individualrights/.

## Appendix 3- Semi Structured Interview Guide for Physiotherapists

Lucy Jane Gillbanks MSCP
MSc Musculoskeletal Science by Research/ Physiotherapist
Telephone number: 07958935661
Email address: lucy.gillbanks@lmh.ox.ac.uk

PHYSIOTHERAPISTS' PERSPECTIVES OF RED-S IN LIGHTWEIGHT ROWING

Background information

1. Thank you very much for participating in my research study before I continue please could I confirm.
2. Your age
3. The year that you graduated as a physiotherapist.

RED-S Awareness

4. Can you provide an overview of your experience working within lightweight rowing?
5. What do you know about RED-S? Definition and symptoms will be provided to the Physio if they haven't heard of the condition.
6. How did you find out about RED-S? Prompt physio course, undergrad course, self-reading, internet, colleagues, personal experiences, other.
7. Have you read any research on RED-S? Prompt if yes, ask for more detail e.g. article, or what they learnt.
8. Do you think RED-S impacts a lightweight rower's performance? In what ways?
9. Do you believe RED-S is well understood by Physiotherapists who work with athletes? Please explain your answer.
10. Who should be aware of the symptoms of RED-S? Prompt parents, healthcare professionals, rower, coach.
11. What strategies or approaches do you think would be valuable in raising the awareness of RED-S amongst Physiotherapists and healthcare professionals.

RED-S Management

12. What are your opinions on educating athletes about the potential adverse effects of exercise?
13. Can you describe your experiences managing athletes with symptoms of RED-S?

14. (If no experience) How would you manage and treat an athlete with RED-S symptoms? Prompt: have you had experience in this? Prompt, diet, body image etc.

15. How would you approach the subject of asking the rower how they are coping with the sport?

16. What is your experience with discussing mental and social issues with athletes? Prompt, social life, mental health.

17. If you have any further comments about your experience with RED-S, that you would like to share, please do so now.

18. Thank you for participating in my study it is greatly appreciated, do you have any questions?

## Appendix 4- Semi Structured Interview Guide for Lightweight rowers

Lucy Jane Gillbanks MSCP MSc Musculoskeletal Science by Research/ Physiotherapist
Telephone number: 07958935661Email address: lucy.gillbanks@lmh.ox.ac.uk

LIGHTWEIGHT ROWERS' PERSPECTIVES OF LIVING WITH RED-S

Background

1. Thank you very much for participating in my research, before we start please could I confirm:
2. Your age?
3. Years of lightweight rowing?
4. Can you provide an overview of your experience as a lightweight rower?
5. What races have you been required to weigh-in for?
6. Can you describe your experience with trying to meet a required weight? Prompt taking supplements, additional vitamins with dieting, extreme weight loss techniques.
7. How long did it take you to get down to your required weight?
8. How long did you have to stay at your required weight?
9. Did do your eating habits change before and after weighing in?
10. If the answer is yes to the above question, in what ways?
11. Can you describe your relationship with food?
12. Can you describe your relationship with exercise?
13. Can you tell me if you are satisfied with your body shape?
14. Can you explain any injuries you have suffered whilst rowing?
15. How was (when rowing) / is your menstrual cycle (females only)?
16. Would you feel comfortable talking to your physio about your menstrual cycle? (Female only) Why/why not?
17. Would you feel comfortable talking to your physio about your sex drive? (Male only) Why/why not?
18. Can you tell me about the quality of your sleep?
19. Does lightweight rowing affect your mood? In what way?
20. How does lightweight rowing impact your life? Prompt social life, relationships- considering both positive and negative.

21. Would you feel comfortable talking to your physio about your mental health? Why/why not?

RED-S

22. What do you know about RED-S? Definition and symptoms will be provided if they haven't heard of the condition.

23. Can you describe your experience with RED-S (including which symptoms you have experienced)?

24. How does/did RED-S impact on your life, inside and outside of rowing?

25. Can you describe the support or treatment you have received for your RED-S symptoms (mention specific symptoms)?

26. Have you got any suggestions as to how RED-S could be managed better amongst the lightweight rowing community? Prompt education, more involvement of healthcare professionals.

27. If you have any further comments about your experience with RED-S, that you would like to share, please do so now.

28. Thank you for participating in my research, do you have any questions?

## Appendix 5- Physiotherapists Recruitment Poster

Lucy Gillbanks
Researcher/ Physiotherapist
Telephone Number: 07958935661
Email address: lucy.gillbanks@lmh.ox.ac.uk
Ethics Approval Reference:
Study: Lightweight rowers' and physiotherapists' perspectives of managing and living with RED-S.

NDORMS

UNIVERSITY OF OXFORD

**PHYSIOTHERAPISTS WHO WORK WITH LIGHTWEIGHT ROWERS NEEDED FOR TELEPHONE INTERVIEW**

### Who can take part in this research?

Registered Physiotherapists with at least 1-year experience working with lightweight rowers in the U.K.

### What will I be asked to do?

- 30-60 minute telephone interview (at a time that suits you)
- Discussion of health implications lightweight rowing has on young athletes.
- Audio-recording of the telephone interview for analysis of the data.
- All data will be kept confidential

### Who do I contact if I want to take part?

If you would like to take part in this research or if you have any further questions, please contact Lucy by email **lucy.gillbanks@lmh.ox.ac.uk** or phone 07958935661.

## Appendix 6- Lightweight Rowers Recruitment Poster

Lucy Gillbanks
Researcher/ Physiotherapist
Telephone number: 07958935661
Email Address: lucy.gillbanks@lmh.ox.ac.uk
Ethics Approval Reference:
Study: Lightweight rowers' and physiotherapists' perspectives of managing and living with RED-S.

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Medical Sciences Division

UNIVERSITY OF OXFORD

# LIGHTWEIGHT ROWERS NEEDED FOR A TELEPHONE INTERVIEW



## Who can take part in this research?

- Have at least 1-year experience in lightweight rowing at an intermediate or elite level
- Males or females, aged 18 years or older
- Have experienced one or more of the following symptoms whilst rowing

  - Reoccurring injuries including stress fractures
  - Menstrual dysfunction
  - Low energy during training
  - You prioritise being lean
  - Excessive fatigue
  - Muscle loss
  - An inability to recover well between sessions
  - Relative Energy Deficiency in Sport (RED-S) diagnosis
  - Female Athlete Triad (F.A.T.) diagnosis

## What will I be asked to do?

- 30-60minute telephone interview (at a time that suits you)
- Discussion of health implications of lightweight rowing.
- Audio-recording of the telephone interview for analysis of the data.
- All data will be kept confidential.

## Who do I contact if I want to take part?

If you would like to take part in this research or if you have any further questions, please contact Lucy by email: **lucy.gillbanks@lmh.ox.ac.uk** or phone **07958935661.**

## Appendix 7- GANNT Timeline Chart

| Task | Oct 2019 | Nov | Dec | Jan 2020 | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Completion of Research proposal | | | | | | | | | | | | |
| Submission of proposal | | | | | | | | | | | | |
| Develop interview guide | | | | | | | | | | | | |
| Develop recruitment poster | | | | | | | | | | | | |
| Develop participation information sheet | | | | | | | | | | | | |
| Submit for ethical approval | | | | | | | | | | | | |
| Complete interviews | | | | | | | | | | | | |
| Transcribe audio-recordings | | | | | | | | | | | | |
| Analyse Data | | | | | | | | | | | | |
| Write Chapter I- Intro and Background | | | | | | | | | | | | |
| Write Chapter II-Method | | | | | | | | | | | | |
| Write Chapter III- Results | | | | | | | | | | | | |
| Write Chapter IV- Discussion | | | | | | | | | | | | |
| Write Chapter V- Conclusion | | | | | | | | | | | | |
| To have completed first draft | | | | | | | | | | | | |
| To complete final draft for proof reading | | | | | | | | | | | | |
| To bind and submit | | | | | | | | | | | | |

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