

1 Title

2 Relative Energy Deficiency in Sport and The Role of Ultrarunning Coaches According to Two
3 Female Ultrarunners

4

5 Abstract

6 Relative Energy Deficiency in Sport (RED-S) is a complex syndrome that occurs as a result
7 of prolonged Low Energy Availability (LEA) leading to health and performance
8 impairments. However, whilst the coach plays an important role when working with
9 athletes with RED-S, no research exists specifically exploring their role. Therefore, this
10 study investigates the role of the coach from the athletes' perspective within an
11 ultrarunning context. Ultrarunners are at risk of LEA due to large training volumes and
12 record high incidences of psychological and physiological conditions linked to RED-S,
13 such as disordered eating and bone stress injuries. Two female ultrarunners who had
14 experience of RED-S each participated in three semi-structured interviews. The findings
15 highlight the multifaceted role of the coach which changes depending on the stage of the
16 athletes' RED-S Journey. Of primary importance was that the coach should be educated on
17 RED-S in order to provide value throughout. Secondly, for effective recovery the coach
18 should embrace working with a multidisciplinary support team of experts. Thirdly, the
19 coach should actively work on establishing strong relationships with the athlete and their
20 support network. This will propagate trust and honest conversations, a key requirement
21 for recovery from, and ongoing training post, RED-S.

22

23 Keywords

24 RED-S, ultrarunning, ultramarathon, sports coaching

25

26 Introduction

27 Ultramarathons are running races longer than 42.2km, with successful performances
28 typically associated with athletes completing high training volumes¹². These training
29 behaviours require a high exercise energy expenditure and will result in low energy availability
30 (LEA) when nutritional intake is insufficient³. Such LEA increases risk factors for Relative
31 Energy Deficiency in Sport (RED-S). RED-S is the result of insufficient caloric intake and/or
32 excessive energy expenditure (EEE)⁴. A large energy deficit caused by EEE or inadequate
33 energy supply can result in a cascade of pathophysiological maladaptive reactions⁵. Negative
34 health and performance outcomes associated with RED-S include impaired bone health,
35 reduced training adaptation, and behavioural/mental-health implications⁶ (Figure 1). RED-S
36 shares underlying aetiology elements of both LEA and Overtraining Syndrome (OTS)⁷. OTS can
37 manifest after a period of high training load, negatively impacting the immune function
38 and/or prolonged fatigue resulting in reduced performance⁸. These complex and intrinsically
39 linked syndromes have many of the same symptoms and thus present challenges in
40 diagnosis⁷. Although an International Olympic Committee (IOC) consensus statement on RED-
41 S exists⁶, the condition lacks recognition by healthcare professionals^{9,10} and coaches¹¹. There
42 is a clinical assessment tool for RED-S¹², however, with, at times, no clear delineation between
43 LEA, OTS and RED-S, athletes, coaches, and healthcare professionals can struggle to correctly
44 identify RED-S⁹⁻¹¹.

45 Identifying prevalence of RED-S is challenging, partly because RED-S is a poorly recognised
46 condition by medical practitioners and coaches^{9,11}. Furthermore, little is known about the
47 role of the coach when working with athletes who are at risk of or suffering from RED-S.
48 Therefore, this study sought to explore ultra-running athletes' experiences of RED-S and the
49 runners' perspectives on the coach's role when managing it.

50

51 RED-S Prevalence and Symptoms

52 There are several conditions with symptoms and aetiologies similar to, or overlapping,
53 with RED-S, such as the LEA³ or OTS⁷. In a study including national and world-class female
54 endurance runners, prevalence of LEA was 28%, with LEA-likelihood increasing the greater the
55 distances athletes' ran¹³. Rogers et al.,¹⁴ identified that up to 80% of elite and pre-elite female
56 athletes exhibited at least one symptom associated with RED-S, whilst over a third, exhibited
57 two or three symptoms. Three common symptoms of RED-S for female athletes are LEA,
58 decreased bone mineral density and menstrual dysfunction, collectively known as the Female
59 Athlete Triad (FAT)¹⁵. Whilst covering some of the potential outcomes of prolonged LEA, such
60 as low bone mineral density, the FAT is not comprehensive enough as it does not include
61 other symptoms that athletes experience. Therefore, the development of RED-S encapsulates
62 the FAT, and highlights further associated physiological and psychological implications (Figure
63 1)⁶.

64 Risk factors for RED-S, such as LEA, bone stress injuries/low bone density, low BMI are
65 prevalent in ultrarunners^{7,16}. In addition, these athletes have a higher risk of disordered
66 eating¹⁷. Whilst the prevalence of RED-S in ultrarunners is not known, Folscher et al.,¹⁸
67 identified that 44% of the ultrarunners in their study were at risk of the FAT. Therefore, with
68 the prevalence of the FAT in ultrarunning, and the intrinsic relationship (as per Figure 1)
69 between the FAT and RED-S, it is important for coaches to learn about RED-S.

70 When RED-S is identified, the multifaceted nature of recovery from RED-S is equally
71 challenging because psychological factors interact in complex ways with physiological ones¹⁹.
72 Psychological consequences may include depression or irritability⁶ and sufferers have
73 discussed being on an emotional roller coaster²⁰. Stellingwerff et al.⁷ suggest a multi-
74 disciplinary support network may be helpful to treat RED-S, however, they recognise that
75 most athletes do not have access to such support. For example, treatment may not be readily

76 available where there are diagnostic challenges, arbitrary clinical-thresholds, and other
77 treatment barriers²¹. Many medical practitioners are inadequately equipped to support sport
78 related conditions and other support staff, such as physiotherapists, have been found to lack
79 knowledge of RED-S and how to manage it²². Whilst it is important to increase the awareness
80 amongst medical professionals, as they are often the primary professional for the athletes'
81 care²³ binary approaches to diagnosing disordered behaviours are not overly helpful²⁴. Rather
82 transdiagnostic approaches to address complex aetiologies are advocated, where suitably
83 trained non-medical people help provide support when resources are limited²⁴. Coaches are
84 one such member of an athlete's support network. Coaches could, therefore, play a critical
85 role in the prevention and treatment of RED-S as they are an important influence on athletes'
86 behaviours, particularly when working on an individual basis²⁵.

87

88 The Coach and RED-S

89 In ultrarunning the coaching process includes prescribing healthy training loads and
90 providing guidance relating to appropriate energy intake. Research, however, frequently
91 focusses on the actions of coaches as a contributor to athletes' poor mental and physical
92 health²⁶ which may heighten the risk of RED-S. For example, negative personal rapport
93 between the coach and athlete, has been shown to raise athletes' anxiety levels²⁷. Female
94 athletes competing in individual sports with an unsupportive coaching environment used
95 disengagement-orientated coping strategies (such as expressing unpleasant emotions) to deal
96 with pressure²⁸. Plateau et al.²⁹ found coaches promoted negative eating behaviours and
97 excess training volumes in the belief that they are critical to performance. Heather et al.³⁰
98 identified that >10% of elite female athletes had been told by their coach that they needed to
99 lose weight. In a study of female physique athletes (athletes judged on symmetrical
100 appearance and low-fat mass, rather than physical performance)³¹, the coach was identified

101 as the greatest influence on dieting behaviour and bodyweight loss³². Multiple studies
102 (e.g.^{33,34}) have demonstrated the potentially harmful power the coach holds in the coach-
103 athlete relationship, and the pressure athletes can feel when trying to speak out on sensitive
104 topics. Furthermore, athletes' maladaptive eating approaches, including disordered eating,
105 have been attributed to pressure from coaches, with the aim of manipulating body size or
106 shape^{35,36}. In contrast, athletes who perceive themselves to be more compatible with their
107 coach have been shown to experience fewer negative emotions³⁷. Furthermore, athletes in
108 individual, rather than team, sports have been shown to have a more committed and closer
109 relationship to their coach³⁸. These findings suggest that the relationship between the coach
110 and athlete may be critical to ensuring there are opportunities for open discussion about how
111 best to train and prepare for ultrarunning performances. In fact, a strong coach-athlete
112 relationship has been shown to mitigate some of the perceived pressure on body weight
113 related to the development or increase in severity of disordered eating³⁹.

114 This evidence suggests the actions of coaches can have a strong influence on athletes'
115 energy availability (EA) through influences on eating behaviour and training load. Energy
116 intake and, importantly, EA are key for both avoiding and causing RED-S. Athletes report
117 several challenges to achieving adequate EA⁴⁰. This includes knowledge of and actual volume
118 of food to be consumed, the financial impact of higher food consumption needs, and lack of
119 time for food preparation and consumption⁴⁰. Moreover, athletes' have perceived coaches'
120 knowledge on nutrition and bodyweight to be insufficient, but advice from dieticians help
121 increase some athletes understanding on these topics⁴¹. It has been argued that coaches and
122 athletes' knowledge is socially constructed and influenced by their relationships⁴²⁻⁴⁴ with
123 varying forms of knowledge influencing athletes' awareness of nutrition differently⁴¹.
124 Consequently, diverse experts, such as a coach or dietician, may impact athletes' nutritional
125 approaches in varying ways.

126 Distinguishing between intentional (disordered eating or eating disorders) versus un-
127 intentional under-fuelling is important because those un-intentionally under-fuelling their
128 training may not be aware of this discrepancy in EA and its consequences⁶. To support
129 athletes, coaches (not athletes) are likely to initiate discussions around fuelling and
130 performance⁴⁰. However, a recent scoping review suggested that training for coaches on RED-
131 S from National Governing Bodies⁴⁵ was not common, albeit considered paramount to
132 support athletes' health. Therefore, although there is evidence that education of coaches can
133 help to identify eating disorders and lead to positive interventions for athletes' health⁴⁶,
134 further research into athletes' 'lived' experiences of RED-S is needed to develop a deeper
135 understanding of the biopsychosocial elements linked to RED-S⁴⁷. Moreover, it should include
136 exploration into athletes' recovery from RED-S²⁰.

137 Therefore, the aim of this research was to explore athletes' perspectives on the role of
138 an ultrarunning coach in supporting ultrarunners with RED-S. Developing this understanding
139 could establish the importance of the role of the coach in RED-S aetiology, prevention, and
140 recovery and assist coaches to better support athletes' performance, health, and wellbeing.

141

142 **Methods and methodology**

143 **Participants**

144 Potential participants were recruited via a post on social media. This sampling was
145 deemed appropriate, as due to the difficulties with diagnosis of RED-S, it was important that
146 participants self-identified as having lived with RED-S and were willing to discuss their
147 experiences. Two female ultramarathon runners responded to the post and subsequently
148 volunteered to participate in this study. Although a small sample, there was no limit set by the
149 authors in terms of numbers or sex, but rather only two female ultrarunners responded to the

150 advertisement within the timescales. This enabled the researchers to explore participants'
151 information-rich experience⁴⁸.

152 At the time of the research both participants were in their 40's, in the recovery phase
153 of RED-S, and not racing, but had plans to continue with the sport once recovered. Whilst self-
154 identified, initial screening revealed both participants were working with multiple experts on
155 symptoms associated to RED-S, such as bone stress injuries, hormonal imbalance, nutritional
156 intake, and menstrual cycle dysfunction.

157 Participant 1 had been competing in ultra-marathons for over 5 years and had won multiple
158 major competitions and qualified for World Championships. She had been diagnosed with
159 anorexia nervosa and had been an in-patient in a specialist treatment centre. This had
160 coincided with a sudden loss in weight, in-part due to a stress fracture meaning training was
161 not possible.

162 Participant 2 had been participating in ultrarunning for two years. She was participating for
163 enjoyment rather than competing for wins and had come from a road running background.

164 Both participants had worked with coaches previously, with Participant 1 working with a new
165 coach at the time of the research. The participants had extensive support networks including
166 professionals such as endocrinologists, medical practitioners (for bone stress injuries),
167 physical therapists, and dieticians. Participant 1 was also working with a psychiatrist.

168 Ethical approval was provided by the General University Ethics Panel of the host
169 university. Participants gave informed consent prior to data collection. Due to the sensitive
170 nature of interviews, the participants were assured that their identities would only be known
171 to the first author. They could also review transcripts and subsequent draft manuscripts to
172 ensure that they felt that interpretation was fair and that they could not be identified by the
173 stories they told. Participant 2 accepted this offer and reviewed her transcript.

174

175 Procedure

176 Following institutional ethical approval, the advertisement was posted on social media, and
177 participants identified for the study. Dates and times for the interviews were arranged to fit
178 with participants' schedules. This resulted in interviews being conducted over a 5-week
179 period. All interviews took place via MS Teams. Interviews lasted between 55 and 70 minutes
180 and were transcribed verbatim.

181

182 Data Collection

183 To enable in-depth exploration of the participants' lived experience with RED-S, three semi-
184 structured interviews were conducted with each participant⁴⁹. This enabled sustained
185 participants' engagement in the study as well as providing time for preliminary analysis of the
186 transcripts between interviews. In doing so, the researchers were able to reflect on the points
187 raised and, in subsequent interviews, follow up on comments and explore additional area⁴⁹. It
188 also allowed participants to reflect on the conversations. This approach resulted in both the
189 interviewer and the participants referring to previous interviews and exploring topics in more
190 detail.

191 Provisional topics for the interviews were developed through reviewing existing literature
192 and, in recognition of the complex 'interdisciplinary' causation of RED-S, using the
193 biopsychosocial model⁵⁰. To encourage the participants to tell their story, the interviewer
194 adopted the role of 'active listener'⁵¹. Active listeners display empathy, understanding, and
195 support the interviewee in sharing feelings and thoughts⁵². A reflexive process⁵³ was used to
196 better understand how the participants experiences influenced their perceptions and
197 understanding of RED-S, its impact on their training and broader life.

198

199 Data Analysis

200 An abductive method of data analysis, generating theories from qualitative data, was
201 used⁵⁴. Abductive analysis facilitates exploration into the degree to which the data upheld
202 existing theories (i.e., deduction), whilst also allowing the freedom to create new
203 understandings or elucidations (i.e., induction)⁵⁵. This approach encouraged qualitative
204 exploration of the complex syndrome of RED-S, its antecedents, and consequences. Through a
205 process of indwelling⁵⁶, the first author became familiar with the content, listening to the
206 audio whilst cross-checking the transcripts to ensure accuracy, followed by reading each
207 transcript twice. Indwelling involves the interviewer conducting the research, and then
208 removing themselves and reflecting on the investigation and findings⁵⁶. After developing an
209 understanding of each participant's experience, the transcripts were reviewed for appropriate
210 quotes relating to the onset of RED-S to return to running, to produce initial codes. Grouping
211 of similar codes was undertaken, creating sub-themes, and this approach was replicated to
212 produce more substantive themes and ensuing predominant categories.

213

214 Trustworthiness

215 The themes and categories were reviewed by all authors to ensure accuracy and
216 improve trustworthiness. Trustworthiness is a term describing the methods adopted to
217 enhance the quality of qualitative research⁵⁷. It relates to the level of credence in the
218 methodologies used and research findings⁵⁸. The first author is a coach with experience and
219 expertise within ultrarunning. His perspective permeated into the research, influencing the
220 questions asked, the data analysis^{59,60} and interpretation. Being immersed in ultrarunning,
221 experience, understanding and perceptions created over time results in greater
222 comprehension and discernment of the culture and causal mechanisms for the participants. In
223 this scenario it is impossible to remove research biases^{61,62}.

224 To improve the trustworthiness, and ensure key points made by the participants were not
225 missed, the second and third author acted as a critical friend (providing critique, alternative
226 perspectives and reducing the likelihood of bias in the research and analysis⁶³) throughout the
227 analytic process, providing balance and facilitating greater reflexivity through appraisal and
228 discussion⁶⁴.

229

230 Results

231 For both participants RED-S is an ongoing journey, from the onset of RED-S to the Lived
232 Experience, and Recovery and Return to Play. Within each of these categories there are
233 themes that are consistent across both participants and their perceptions of the role of the
234 coach. The findings highlight the complexity of RED-S, with the role of the coach, in the eyes
235 of the athlete, changing throughout the journey. The coach is at times seen as an ally, able to
236 assist where appropriate, but the participants had also experienced negative influences from
237 coaches.

238 The Onset of RED-S

239 The consistent themes identified influencing the onset of RED-S were psychological
240 drivers, educational influence, sport-specific pressures, physiological drivers and social
241 environment (see Table 1). Participant 1 reflected on a *perceived need for control, social*
242 *approval and restrictive eating practices*: “I would say that I have always been controlling, and
243 sometimes restricting for that matter, my eating since my teenage years. I was always worried
244 about my appearance, thinking I am not in shape, looking too fat.” Participant 2, however,
245 experienced LEA due to *unintentional under-fuelling* and being *unaware of the risks*: “I was
246 trying to achieve the same level of performance and gain I had on that nutritional pattern, and
247 I didn’t understand that that wasn’t sustainable.” There were differences in the onset of RED-

248 S, with Participant 1 having been clinically diagnosed with a pre-existing eating disorder whilst
249 Participant 2 was *unintentionally under fuelling*.

250 Both participants discussed *low self-worth/self-respect*. Their beliefs were not linked to
251 sporting performance, but to appearance and a fear of 'being fat'. However, the impact of
252 training and the surrounding environment was prevalent, with *training culture* along with the
253 *training demands*, and a mindset that being *lighter is better* important to them. These beliefs
254 were influenced by *pressure from coaches*.

255 "We would always kind of try to restrict eating to become lighter. And we were also
256 encouraged by our coaches to do this to a certain degree... but no one was aware back then
257 that this is RED-S' (P1)

258 **Consequently, with an increased training load training maladaptation resulted in an**
259 **acknowledgement that something was wrong. "I tried to up my training to sustain something I**
260 **had achieved.** But because I didn't get the gains from it, I was like 'well I must be eating too
261 much', but in actual fact I wasn't fuelling my body enough" (P2). Initially, both participants
262 were *unaware of the risks* or of RED-S, however, acknowledgement helped change this: "I
263 think that when you understand something, that means you're going to have a different
264 relationship with it."(P2).

265

266 The Lived Experience of RED-S

267 Living with RED-S comprised three themes: physiological impact, psychological impact
268 and social impact (see Table 2).

269 Both participants experienced *bone stress injuries, menstrual dysfunction, gut health issues,*
270 and *hormone imbalances*. "The endocrinologist is helping a lot on this. They're also kind of
271 explaining the link between bone health, health, weight, and hormones." (P1)

272 Furthermore, these symptoms, especially the injuries, led to *frustration* coupled with a *desire*
273 *to exercise*; “I was still walking 10km everyday to make sure I was ready to run a race. When in
274 actual fact I had stress in my bone” (P2). “I was doing cycling and I was doing weight training
275 and so on because no one really said ‘hey, this is the point where you need to stop and you
276 need to gain weight.’ Only then, when the stress fracture did not mend, and we started to
277 realise that there is more not OK than just a stress fracture and I needed to stop training” (P1).
278 *Social interactions* around appearance and weight and concerns over *body image*, and
279 increasing weight linked to lower training volume, were frequently mentioned. *Social*
280 *interactions* were sometimes uncomfortable as they could result in discussions around body
281 weight and eating; “many people made remarks around, well, you know, - ‘I think you're a
282 little thin, you should be eating more’” (P1). Participant 1 highlighted the interconnected
283 nature of RED-S. “This disease is so complicated. Especially when, well, especially when you
284 have an eating disorder that is underlying RED-S. There are so many different experts that
285 help in different areas and only when putting all of that together it will actually become
286 something that is useful and is helping me to address the eating disorder and RED-S.”

287

288 The RED-S Recovery Journey

289 The RED-S Recovery journey comprised six themes: education, training changes,
290 support network, coach support, psychological adaptations, and challenges (see Table 3).

291

292 The participants relied on *social networks*, including friends, their coach and family. They
293 augmented guidance from experts including *nutritionists, medical practitioners, psychologists,*
294 and *physiologists* with research of their own. Coaches were sometimes encouraging and
295 helped orchestrate guidance/information that was linked to ultrarunning or training.
296 Participant knowledge changed the relationship they had with RED-S and was partly

297 responsible for an initial *stop to training* before returning with a *reduced load*. Additionally, it
298 resulted in nutritional changes that saw an *increased energy intake*, proactively *fuelling*
299 *workouts* and optimising *nutritional timing*: “Understanding that if I do bring these three
300 elements together, so training smarter, respect recovery and fuel well before, during and
301 after training, then actually it does help with getting better training adaptation” (P1).

302 The recovery journey included adopting the *expert advice* of a *reduced load* and
303 *reframing training load*. Doing so included understanding that previous volumes were
304 unsustainable. Coupled with lower training volumes, *reframing goals* was important to their
305 recovery strategies “acknowledging that there are different training sessions and different
306 goals for each of the training session and not every session needs to be a very tough one”
307 (P1).

308 Participants perceived that certain experts had *limited understanding of RED-S*: “I
309 don’t think that many of them give a very comprehensive view, if at all” (P1). This resulted in
310 participants orchestrating the support process themselves, making sense of differing advice
311 and perspectives, which focused on treating the signs and symptoms of the individual
312 pathology that related to the boundaries of practitioner expertise. *Maladaptive temptations*,
313 such as “not eating properly” (P1), were present, especially when the participants felt the
314 support network was not performing at a level they would have liked.

315 The role of the coach support was deemed crucial. For Participant 1, her coach “was adamant
316 about something being very wrong with my health and my eating. He insisted that I seek
317 medical help which I finally did.” A coach knowledgeable on RED-S was instrumental in
318 *providing guidance/information* for both athletes “Because as a client you could also have
319 absolutely no awareness at all of this thing called RED-S” (P2). At times they served as a
320 *broker*, introducing the athletes to relevant experts, or resources; “My coach introduced me
321 to the Sports Dietician and their team, that helped a lot as they talked to me about recovery

322 and training” (P1). Furthermore, the support of the coach was successful when providing a
323 *balanced/integrated view* that at times served as an *anchor to running*, by discussing support
324 to and providing a link “back to running, always showing me the link between the intervention
325 and the impact it will have on my running” (P1). However, participants suggested that experts
326 could be *suspicious of the coach* and that they were a negative influence on body weight: “I
327 always need to defend my coach a lot in front of the eating disorder specialist”(P1).

328

329 ‘Return to Play’

330 The themes identified influencing ‘Return to Play’ were successful support, coach’s
331 role, and independence (see Table 4).

332 Participants valued support in which professionals were *responsive* and demonstrated broad
333 *expertise*. *Clear communication* and knowledge helped develop *trust and respect in*
334 *relationships*. Furthermore, participants valued practitioners who were *athlete-centred* and
335 recognised the importance of *performance* – i.e., they spoke to the participant as an athlete,
336 not as a patient: “I think anyone who comes more from a sports perspective has been more
337 helpful than the others” (P1).

338 Moreover, there were *agreed goals*, the support network would work in partnership
339 with the participants and were open to discussion: “Everybody has been very receptive to all
340 my questions. All of my curiosity” (P2). Another key attribute for successful support centred
341 on *clear roles* and *integration* between the experts as Participant 2 explained: “The experts
342 will also direct me to the correct person to clarify something... Everyone respects their
343 professional boundaries and their... limits in their knowledge and they welcome the input
344 from the other specialists, which is really amazing.”

345 However, the participants recognised that there would be *less expert involvement in*
346 *the future*, whilst acknowledging their desire to draw upon their support network when

347 required. Participants recognised that their increased knowledge of RED-S and its symptoms
348 gave them more autonomy: “You can do strength and conditioning, you can run, but it's
349 finding a sustainable way to do that and that's I guess what I'm doing at the moment” (P2).

350 Participants believed that the coach-athlete relationship was central to the ‘return to
351 play’. They recognised that coaches would support *sustainable training, safe training* and
352 highlight *maladaptive training practices* when doing so. Through *clear communication* and
353 *clear expectations/role* within the coach-athlete relationship, this would reduce the risk of the
354 return of RED-S: “I guess what helps is if the coach is pointing out when kind of these wrong
355 behaviours come into play and they're being very honest and blunt, right? Even though I get
356 upset” (P1). *Shared decision making* was also a component that participants believed was
357 beneficial and a key element of the coach’s role. Through “discussing the options, removing
358 any which I propose that the coach knows are non-beneficial and then discussing with me the
359 alternative options” (P1) athlete buy-in is achieved for the decisions made. Participants
360 recognised that coach education was important to help them understand RED-S and to
361 develop the requisite skills to apply their knowledge:

362 “the academic curriculum definitely needs, in my opinion, to equip coaches with the very basic
363 knowledge and information that you need in order to have the awareness around RED-S” (P1).

364 *Holistic coaching practice* was also important in this regard: “I think it's a coach that
365 can help ensure you're considering all aspects in a rounded way and treating your body as an
366 integrated whole, which again is potentially easier said than done” (P2).

367 However, it was acknowledged by Participant 1 that, whilst a *holistic* approach is
368 favoured, “unfortunately still a lot of coaches limit their coaching activities on just the
369 performance aspect regardless of any health aspects or happiness aspects or mental aspects.”

370 Whilst *clear expectations/roles* were important to define, Participant 1 reflected on
371 the ideal role for the coach, acknowledging this did not reflect her experience:

372 “Ideally the coach can also help the athlete understand where this help can be found...
373 basically being a bit of a broker of information... I don't think it should be the athlete’s
374 responsibility to link different experts and source this information back to the coach. But this
375 is actually reality, because only as an athlete, or as a patient, you are seeing all these experts
376 and you develop the first-hand relationship.”

377

378 Discussion

379 This study sought to provide insight into athletes’ personal and social experiences as
380 ultrarunners with RED-S and their perspective on the role of the coach. The findings
381 demonstrate greater prominence of the importance of their social network, including
382 coaches, than is reflected in the literature (e.g., Mountjoy et al.⁶), and that they are
383 fundamental to manage complex aetiologies²⁴.

384

385 The Participants’ RED-S Experience

386 The participant narratives confirm that RED-S is a multi-faceted condition which is not
387 susceptible to simple description or explanation. The challenges in definition, diagnosis of and
388 delineation between similarly complex conditions such as LEA, OTS and RED-S^{7,9,10} are likely
389 to remain elusive unless there is greater recognition of the ontologies used to construct
390 knowledge of complex aetiologies. The data in this study demonstrated that causality and
391 treatment of RED-S emerges through complex biological, psychological, and social
392 interactions. Thus, arbitrary diagnostic thresholds may not be best suited when working with
393 ultrarunners with RED-S.

394 Participants discussed clinically diagnosable conditions including bone stress injuries,
395 and menstrual cycle dysfunction⁶. Additionally, exercise dependency, a separately diagnosable
396 condition⁶⁵, is often linked to RED-S and makes treatment more challenging. The participants

397 struggled to cope with reduced training volumes, with stress negatively impacting recovery in
398 athletes⁶⁶. The participants also highlighted the impact of psychosocial elements including
399 limited social engagement and comments on their appearance. For example, P1 failed to
400 manage the cause of her stress fracture, by cycling and strength training to control her weight.

401

402 The Role of the Coach

403 The participants perceived the role of the coach as changing throughout the RED-S
404 Journey and a key member of a support network. The findings highlight that multi-disciplined
405 treatment teams are required, echoing the findings of Stellingwerff et al.⁷, whilst revealing
406 that the team must not demonise the coach, and embrace an integrated approach. Moreover,
407 the coach, or other individuals within the treatment team, must help the athlete with
408 introductions to relevant experts.

409

410 Coach Education

411 The participants articulated that awareness and understanding of RED-S within their
412 social networks, and with some of their previous coaches, was poor. This finding is consistent
413 with the literature, which suggests increased awareness and education can help in the
414 prevention of syndromes such as OTS and RED-S^{6,45,67}. The recommendations of Bar et al.⁶⁸
415 for more education on eating disorders are typical in this regard. However, researchers in
416 many areas relating to sports performance and health will suggest that other people need to
417 be educated in their disciplinary interest, without considering the pathways to deliver this
418 education or coaches' preferences for learning. However, ultrarunning is a relatively new
419 sport, where limited traditional governing bodies exist to deliver education. Furthermore,
420 coaches prefer to learn through experience and unmediated sources^{69,70} rather than formal
421 pathways. Few ultrarunning coaches or athletes are in well-funded professional programmes

422 with access to multi-disciplinary teams or have the skills to administer screening tools such as
423 the Low Energy Availability in Females Questionnaire⁷¹ or the RED-S Clinical Assessment
424 Tool¹².

425 Solutions partly emerged when athletes worked to reframe training loads and goals
426 with their coaches. Coaching beliefs surrounding training loads can be part of the cause of
427 RED-S. Furthermore, the signs, symptoms and causes of RED-S are often shared with other
428 syndromes such as OTS. Therefore, approaches to management of signs and symptoms will
429 also be similar. Such approaches require a comprehensive understanding of appropriate
430 training load, nutrition, menstrual function and what to do when things go wrong. Therefore,
431 developing better coaching knowledge relating to the dose-response to training load may be
432 salutary in terms of performance and health, and could be considered a transdiagnostic
433 approach to multiple conditions.

434 Greater recognition that the coach will often orchestrate processes to prevent,
435 manage and treat RED-S may be fundamental to successful outcomes in some cases.
436 Notwithstanding, a previous coach of P1 believed that disrupted menstrual function was a
437 positive thing. However, P1 felt the need to defend her subsequent coach when the
438 practitioner providing treatment assumed that he was a negative influence on body mass. This
439 was despite it being the coach that had suggested the athlete sought help. Both participants
440 reported a lack of cohesion and communication within their support network, which was
441 detrimental to their recovery. This suggests that medical professionals will often prescribe
442 interventions without adequate appreciation of the role of the coach in tackling the causes of
443 illness in sport. Co-creation of interventions between coaches, athletes and medical
444 practitioners is advocated, in which learning is likely to emerge from collaboration.
445 Furthermore, transdiagnostic approaches advocated by Patel et al.²⁴ may be better suited in

446 the management of complex conditions where resources are low and specialist guidance is
447 provided on an irregular basis.

448

449 Training Loads and Eating Behaviours

450 There were different levels of intentionality in training-load management and fuelling
451 behaviours between the participants. This finding was consistent with Bloodworth et al.⁷² in
452 elite gymnastics, who suggest that extreme training and eating behaviours may be desirable
453 and functional to an athlete's performance. Thus, the capability to control or manipulate their
454 disciplined eating practices can be viewed as a performance requirement rather than a
455 pathology. Some athletes may be willing to compromise medium-to-long-term health for
456 short-term performance⁷³. If the pervading performance discourse relates to high-load and
457 low-mass, then the coach and athlete may ignorantly conform to such customs, where
458 compliance is based on partial or slanted information⁷⁴. The panacea for both athletes in this
459 study occurred when RED-S became non-functional, and they committed to treatment
460 because of more physical manifestations of the syndrome. The participants highlighted a
461 coach, and support in general, as more efficacious when linking support to running and
462 performance. 'Safe' and 'sustainable' were two common terms used by the participants when
463 discussing their return to running and ongoing training behaviours. This collaborative
464 approach, with expert input from areas identified in Table 4, may enhance training, through
465 embracing a holistic attitude linking to what is important.

466

467 The Coach-Athlete Relationship

468 Bloodworth et al.,⁷² suggest that the level of autonomy athletes have in choosing their
469 behaviours is key. The coach-athlete relationship is key to this autonomy, with the 4C's,
470 Closeness, Commitment, Complementarity and Co-Orientation, of a successful Coach-Athlete

471 relationship⁷⁵ highlighted throughout by both participants. Specifically, Co- Orientation
472 involves agreeing shared goals and effective communication, factors that both athletes agreed
473 were important in their coach relationship and recovery process. Furthermore, respect, trust
474 and compassion were highlighted by the participants as fundamental for the coach-athlete
475 relationship. Jowett & Cockerill⁷⁶ suggest that, although a professional partnership exists, the
476 presence of these feelings, on both sides, establishes the bonds required for generating a
477 close environment. Through developing Closeness, the coach will be better placed to support
478 their athletes through greater understanding, especially from a psychological and social
479 perspective. Emotional health is also reflected in Complementarity through providing
480 emotional support⁷⁷. Both participants expressed frustrations and concerns around their
481 clinically desired weight gain as these contradicted beliefs surrounding training volume and
482 low body mass. The coach, through developing Complementarity within the relationship, can
483 act as emotional support, helping further improve the relationship. This could help show the
484 athlete the coach's Commitment to their recovery and return to the sport. Moreover, a strong
485 coach-athlete relationship will allow for open and sometimes challenging conversations. The
486 desire for high volume training and hard-to-lose beliefs surrounding race weight, have
487 potential for regression in behaviours that lead to maladaptation and the return of RED-S²⁰.
488 Coaches need to recognise the complex aetiology of RED-S where athletes may not always
489 behave rationally or logically, potentially resulting in training behaviours which lead to
490 maladaptation. Through the development of a strong relationship, and awareness of not just
491 the physiological, but also socio-psychological elements, the coach can provide true value by
492 promoting health and wellbeing in addition to performance.

493

494 Limitations and Future Directions

495 As with any research, there are limitations. Whilst this paper focussed on the athletes'
496 perspective of RED-S and the coach's role, the coach's perspective remains unexplored.
497 Indeed, this appears to be a limitation of many original research pieces with one journal
498 publishing over 1100 studies in sports and physiology, with less than 0.5% investigating the
499 coach⁷⁸. The small sample size of female ultrarunners may not be reflective of the experience
500 of other athletes who have experienced or currently have RED-S. Therefore, future research
501 should examine the lived experiences of other endurance athletes including male
502 ultrarunners, as well as athletes competing in other sports. The first author's link to and
503 knowledge of ultrarunning is likely to have influenced the interpretation of the data. However,
504 although this may be viewed as a limitation, his 'insider' knowledge was also helpful in
505 building rapport with participants and understanding of their experiences. Furthermore, the
506 second and third authors input sought to reduce bias and the review of her transcript by one
507 participant provided an opportunity to ensure fidelity in the interpretations of the data.

508 Based on both the limitations and the findings within the current study, several potential
509 areas for further research are proposed. First, researchers exploring RED-S may benefit from
510 involving coaches who have experience of working with athletes with RED-S as they are an
511 untapped resource across sports studies⁷⁸. Furthermore, with limited structured educational
512 programmes for ultrarunning coaches, there is an opportunity to research how coaches learn
513 about RED-S and how athletes construct their knowledge on nutrition and RED-S⁴¹. This may
514 help inform more structured education programmes going forward. Secondly, quantitative
515 and physiological research is dominant in the area of RED-S, and therefore further research
516 investigating the socio-psychological elements of RED-S is required²⁰. Adopting a mixed
517 method approach may prove of value due to the complex integrated nature of the syndrome.
518 There is limited application of this to date, but the work of Schofield⁷⁹ integrating quantitative

519 research to explore the physiological impact and qualitative research for socio-psychological
520 impact, provides evidence of the advantages of such an approach. Finally, although female
521 ultrarunners were selected for the reasons previously given, male athletes are
522 underrepresented^{67,80} and should be considered in future RED-S research.

523

524 Conclusion

525 For the first time, this investigation provides an insight into the role of a coach, from
526 an athlete's perspective, when working with ultrarunners that have experienced RED-S.
527 Illustrating this complex biopsychosocial condition, the current research underlines the critical
528 role of a multidisciplinary framework of experts to assist athletes' recovery and 'return to
529 play.' Key to this coach support is appreciating the multifactorial, namely the biological,
530 psychological, and social elements influencing the syndrome. The coach's role changes
531 depending on where the athlete is on their RED-S journey, however, underpinning all stages is
532 improving coach education to allow coaches to provide appropriate support.

533 Ultrarunners with RED-S are looking to return to training and racing without prolonging or re-
534 encountering the negative impacts they have experienced. To facilitate this, the coach must
535 develop strong relationships with the athletes and experts involved in their recovery from
536 RED-S. Only by embracing the expert knowledge and incorporating it into the support, do they
537 provide the appropriate level of help. The coach should ensure that this information is linked
538 to running, making it meaningful for the athlete, whilst also involving the athlete in shared
539 decision making, thus ensuring their buy-in. By incorporating the multiple sources of
540 information, including the athlete, the value a coach can bring will be enhanced, and will
541 benefit their recovery and ongoing post RED-S ultrarunning.

542 Declaration of interest statement

543 There are no potential conflict of interest

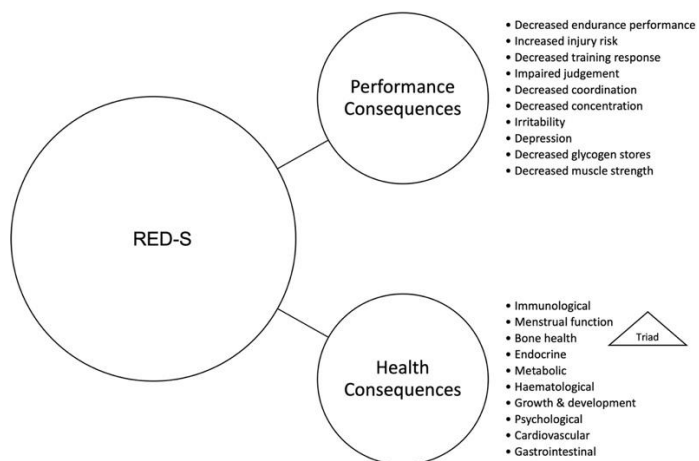
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- 744



745

746 Figure 1. Performance and health consequences of RED-S (adapted from Mountjoy et al., 2018).

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748

749 Table 1 Categories, Themes and Sub-Themes linked to the Onset of RED-S

Category	Theme	Sub-theme	Example Raw Data Code
The Onset of RED-S	Psychological Drivers	Perceived Need for Control	Then it's also linked to control and being able to control myself and being in charge of myself.
		Restrictive Eating Patterns	I have been a lacto-vegetarian since I was twelve and have always been a picky eater with orthorectic tendencies... A couple of years back I started to be even more selective with what I eat, then becoming a Vegan.
		Pre-Existing Eating Disorder	I was diagnosed with anorexia nervosa that has been there since teenage years but was compensated for most of my life.
		Low Self Worth/Self-Respect	My biggest limiting belief would have been I grew up with a good body, but I was physically not, i.e. my face, was not attractive... So probably part of my exercise focus was like, that's the really good bit, I am going to make the best of it.
	Educational Influence	Unintentional Under fuelling	It's not like I couldn't afford to feed myself properly or make some considered choices.
		Unaware of the risks	But equally I wasn't aware of the topic, so somebody could have asked me and it just passed me by.

	Sport-specific pressures	Training Demands	The coach wrote training plans for me and was delighted how many kilometres I could run a week without getting tired.
		Pressure from coaches	I can remember, you know, coaches saying 'well, if you don't have a period that's actually a good thing.
		Increased training load	And that at one point in time did not work with the long distances that I was running.
	Physiological Drivers	Training Maladaptation	And initially my performance was getting better, but it was a very fine line. My foot started to be sore, but I ignored it, carried on training hard and not looking after my body.
		Lighter is better	Getting a better sports performance in an upcoming competition if having lots of hard sessions and hitting the wall constantly, being lighter and having more muscles and less body fat.
	Social Environment	Training Culture	The coach never really checked on me – what is the weight, do you have a period, what do you eat, how do you sleep, are you taking recovery seriously, is something hurting, etc.
		Social Approval	I can remember actually someone a couple of years back saying to me, 'well, you have a little fat around your thighs. I can show you some exercises how you can get rid of them.'

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751

752 *Table 2 Categories, Themes and Sub-Themes linked to the Lived Experience of RED-S*

Category	Theme	Sub-theme	Example Raw Data Code
The Lived Experience of RED-S	Physiological Impact	Bone stress injuries	I've also learned how rare it is for someone to have any form of stress in their femur.
		Menstrual dysfunction	Probably my period stopping was a thing that tipped it over.
		Gut health	Having now seen my nutritional laboratory tests, my gut health is so poor.
		Hormone imbalance	You know, hormones not being in order, and that also having the proof because it's being monitored and

			measured and knowing that when hormones are not OK then bones cannot mend.
Psychological Impacts	Body Image		My love for fashion probably means I didn't really want to gain weight.
	Desire to exercise		I always had to squeeze-in that second workout, and I would focus on the training and not on the recovery.
	Energy Intake Offset		You've got some kind of occasion, and you know you're going to eat stuff that you wouldn't normally eat. I probably would have gone and trained a bit more to compensate
	Frustration		And a few months is a long time and granted I got off my crutches at the end of last week and it has reduced, but a few months is a long time to be on crutches.
Social Impact	Social Interactions		Some people comment on your body when you get leaner, and they think that leaner is better.
	Social Engagement		I couldn't drive to go anywhere.

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754

755 *Table 3 Categories, Themes and Sub-Themes linked to the RED-S Recovery Journey*

Category	Theme	Sub-theme	Example Raw Data Code
The RED-S Recovery Journey	Education	Expert Advice	I think the people that I've spoken to about the topic - you can quickly determine the people that actually understand it and have a... you know, a full understanding.
		Personal Research	I like to read up on scientific papers around the topics so that I have a, let's say, I'm reassured that this is actually information that has a... is grounded in scientific evidence, and has some validity.
	Training Changes	Stop Training	I had to stop training because of the stress fracture, and then it would not mend and then people saying, 'well you can forget about

			any competition in the next 12 to 24 months.'
		Reduced Load	My new coach reduced my training and started to ask all those questions I did not want to hear.
Support Network		Nutritional Experts	Having started now working there with a Sports Dietician does help too because it's very applicable to my situation and how to overcome RED-S.
		Medical Experts	The endocrinologist, is helping a lot on this. They're also kind of explaining the link between bone health, health, weight and hormones.
		Psychological Experts	Often this is being addressed by the nature of conversations in the psychotherapy with the psychiatrist or psychologists.
		Social Network	I have one friend who is actually currently just cooking lunch for me all the time and I have to visit her for lunch and then we just eat 30 minutes and then I leave again.
		Physiological Experts	The consultant took my medical history, completed a physical examination of where the pain was in my leg and referred me for an MRI scan.
Coach Support		Raised the alarm	My coach insisted on something being wrong and me needing to seek medical help to get checked for RED-S
		Broker	Plus a couple of times my coach has introduced the experts to me, so that is a bit different, as they are already known and trusted.
		Anchor to running	Grounding it in running, so making that direct link between the advice and sport
		Providing Guidance/ Information	So it was first of all very much learning and understanding - reading up on it and that was basically being enabled by my

			coach, sending me information about it.
		Balanced/Integrated View	I think the most comprehensive view and also the most balanced view probably would come from the coach - because they put it all together. Not only from a performance perspective, but also from a health, well-being and happiness perspective.
	Psychological Adaptations	Reframing goals	I go like, 'well, why should I eat today more so I can do a competition in three years from now.' So that did not click in my brain. But when then we started breaking this down and say well maybe there is another goal that we could put into later in this year if things are going in the right direction.
		Reframing training loads	The hours that I train less are probably taken up by recovery, which I have not taken any consideration in the past. And ultimately the performance will probably be the same, or most likely even be better, than when I trained until I dropped in every session.
	Challenges	Lack of Integration	I guess a closer coordination would be beneficial for me.
		Gatekeepers	But I can, depending on how honest I want to be or what I want to hear, I can tweak this slightly so there are loopholes for me.
		Suspicious of the coach	When initially, as a coach, you're always very suspicious to any eating disorder specialist, because they tend to think that the coach is actually kind of supporting weight loss and promoting this.
		Maladaptive temptations	I guess if I would not monitor myself or be monitored so closely, I probably would default back to not eating properly again, because I still prefer being lighter and I also still prefer not eating, or not eating enough.

		Limited Understanding	So it's depending on the expert, always the angle where they are expert in is the most pronounced.
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758 *Table 4 Categories, Themes and Sub-Themes linked to the 'Return to Play'*

Category	Theme	Sub-theme	Example Raw Data Code
Return to Play	Successful Support	Responsive	And they've been hugely responsive. Addressing my emergent concerns with pace and rigor.
		Expertise/Experience	But then came the game changer moment, which was the consultant appointment, who again, held the depth of knowledge in the topic, and had masses of experience.
		Athlete Centred	They have been very person centred, or patient cantered.
		Trust and respect	I think what has been helpful in my recovery process are relationships that are based on competency, trust, commitment, and empathy or maybe rather rationale compassion.
		Integrated Network	Everybody/everything else has been very much an integrated.
		Agreed goals	So I think it's very much connected to being competent, and then being able to show me small successes and goals, towards which I should be working.
		Performance Focus	I think anyone who comes more from a sports perspective and has been more helpful than the others.
		Clear Roles	Their network and their referral out to others as needed.
	Coach's Role	Sustainable training	I accept the phenomenal support I'm receiving and I will rebuild my body in a sustainable way.
		Safe training	So am I training in a way that's safe for my body. That's my primary thing, and being heard
		Respect, Trust and Compassion	I hope that the coach relationship, the mutual respect and the trust in

			each other will continue to grow as we embark new challenges.
		Highlighting maladaptive practice	Making sure that I understand if things do not go well, and with that there is also this obligation that comes around telling me when I should not be training or when I should be training less because my health status is not allowing for that.
		Understanding of RED-S	To be able to find out more when you have an athlete potentially facing this.
		Clear Expectations/Role	So my expectations would be that my coach first of all keeps telling me that I have responsibility over my health myself and that I cannot delegate this responsibility to anyone
		Holistic	But in a coach role or job definition where there is a more holistic approach towards the athlete, not just performance, but it's also about health. It's about having a balanced life. Having a happy life.
		Shared Decision Making	We come to a decision together. That works really well as it gets my buy-in.
		Clear Communication	Even though it means potentially difficult conversations, and having unpleasant discussions is probably also something that I would want to have, well I don't want to have them, but if we need to have them, it's better to have them...
	Independence	Increased knowledge	So over time, I think this has developed quite a bit. Not just the awareness, but also the knowledge around this.
		Less expert involvement	So yeah, I anticipate it will always all be there, but just at different levels of dominance or in terms of where you're spending your time and focus.

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