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Are Coaches of Female Athletes Informed of Relative Energy Deficiency in Sport? A Scoping Review

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In the last decade, there has been greater appreciation of the harmful consequences of Relative Energy Deficiency in Sport (RED-S), particularly in adolescent female athletes. Coaches act as both important moderators in the development of the condition and as identifiers of athletes at risk. Research suggests that coaches lack knowledge on this topic. At present, it is unclear if RED-S education is incorporated into coach accreditation pathways. The aim of this scoping review was to describe the extent to which RED-S education is incorporated into the coach accreditation pathways of endurance sporting organizations. Five national sporting organizations (Cycling Australia, Athletics Australia, Swimming Australia, Triathlon Australia, and Rowing Australia) were contacted to participate. First, each sporting organization's website was scoped, then semi-structured interviews were conducted online. One investigator transcribed each interview verbatim. Transcripts were analyzed for thematic content. Four of the sporting organizations provided little to no RED-S education. Rowing Australia delivered a program of RED-S content via an affiliated sports dietitian. The barriers identified for implementation of RED-S content were: limited time, resources, and coaches' preexisting knowledge and beliefs. Based on these results, RED-S education is, indeed, lacking in some coach accreditation programs for endurance-based sporting organizations. Support for these organizations is required to overcome existing barriers and to facilitate inclusion of RED-S education within the coaching curriculum to support female athlete health.

Keywords: coach education, endurance sports, female athlete triad, low energy availability, RED-S, sporting organizations

It is widely acknowledged that regular participation in sport and physical activity has positive physical and psychological health benefits (Eime, Young, Harvey, Charity, & Payne, 2013). Specifically, for adolescent athletes, sports participation has been associated with improved self-esteem and body image, greater bone mineral density, enhanced social interactions, and better academic outcomes (Thein-Nissenbaum & Hammer, 2017; Troy, Hoch, & Stavrakos, 2006; Valois, Zullig, Huebner, & Drane, 2004). However, adverse health outcomes can develop through sport participation with demanding exercise regimes, often arising as levels of competition increase (Melin, Heikura, Tenforde, & Mountjoy, 2019; Torstveit, Fahrenholtz, Lichtenstein, Stenqvist, & Melin, 2019). In some circumstances, there may also be greater pressure on athletes to achieve a particular physique (i.e., compliant with the sporting ideal), which can promote undesirable health effects (de Oliveira Coelho, de Abreu Soares, Ribeiro, & Gonçalves, 2010; Galli, Petrie, Reel, Chatterton, & Baghurst, 2014).

In the last decade, there has been greater appreciation for the harmful consequences of Relative Energy Deficiency in Sport (RED-S), particularly in adolescent female endurance athletes (Holtzman, Tenforde, Parziale, & Ackerman, 2019; Logue et al., 2020). RED-S is characterized by an athlete's energy intake not matching their total exercise expenditure, resulting in a state of low energy availability (LEA) (Logue et al., 2020). Prolonged periods or repeated acute (during the day) bouts of LEA can impair metabolic rate, menstrual function, bone health, immunity, protein synthesis, cardiovascular function, and mood (Mountjoy, Sundgot-Borgen, et al., 2018). Without early intervention, individuals risk

significant long-term health effects, such as increased susceptibility to stress fractures, osteoporosis, infertility, impaired endothelial function, and suppressed immune function (Mountjoy, Sundgot-Borgen, et al., 2018). Accurate measures of the prevalence of LEA continue to present a challenge in clinical practice due to frequent inaccuracies in both energy intake and exercise energy expenditure calculations (Keay, Francis, & Hind, 2018) and variability in techniques used to determine energy availability (EA) (Logue et al., 2020). Nonetheless, recent studies have estimated prevalence rates ranging from 22% to 58% (Logue et al., 2020), with a high percentage of endurance athletes (60%) experiencing menstrual disturbances (Melin et al., 2019).

Given the long-term adverse health effects of RED-S, individuals with the potential to influence EA must act as important potential moderators in the development of the condition (Wells et al., 2020). Coaches typically dictate the energy demands of training and are often in a prime position to observe changes in an athlete's health and performance (Kroschus, DeFreese, & Kerr, 2018). Thus, coaches are likely to be key figures in the identification of athletes at risk of long-term LEA (Ackerman et al., 2020). Furthermore, coaches have the potential to play a constructive role in influencing the knowledge, beliefs, and attitudes of their athletes toward RED-S. However, previous research suggests that coaches lack knowledge and understanding of the condition (Logue et al., 2020). Additionally, coaches do not adequately perceive the seriousness of the detrimental health effects of long-term LEA on female athlete health (Lassiter & Watt, 2007). This may partly reflect an absence of RED-S education and/or professional development being delivered via coach development programs.

National sporting organizations (NSOs) have an obligation to develop professional development pathways and educational resources that support coaches to positively influence athletes' health, well-being, and performance within their sport (Mountjoy, Costa,

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et al., 2018). Recent reports indicate that only 7% of the International Olympic Sport Federations endorse some form of educational material specifically related to RED-S (Mountjoy, Sundgot-Borgen, et al., 2018). To date, no information exists on the delivery of education and/or the professional development activities available to Australian coaches (via the coaching pathways) concerning RED-S.

Therefore, the aim of this scoping review was to identify how (if at all) RED-S-specific educational content is currently incorporated within accredited coaching pathways for popular endurance sports in Australia. This information will be used to determine the suitability of current education and professional development programs, identify where deficiencies exist, and highlight opportunities for implementation of activities and resources to further support female athlete health and performance.

Methods

This scoping review formed an initial study of a program for research, which is underpinned by the public health bicycle framework approach for the development of health interventions

(Hughes & Margetts, 2012). This study was part of the intelligence phase, which is conducted prior to the implementation of a health initiative, which is then subsequently evaluated (Hughes & Margetts, 2012). The review sought to identify all RED-S- and LEA-related content provided by Australian NSOs within the coaching accreditation programs of popular endurance sports. The study was approved by the Human Research Ethics Committee (approval number 2020/302). Figure 1 outlines the four-stage pragmatic approach adopted for the review.

Step 1: Identified Sports, Target Population, and Sporting Organizations

Peer-reviewed original research articles and gray literature were reviewed to identify the sports for inclusion, the target population group, sporting organizations involved, and their country of origin. Peer-reviewed original research articles were identified through the online databases CINAHL, Google Scholar, PubMed, and SPORT-Discus using the following search phrases: “low energy availability (LEA) in sport,” “athletes at risk of LEA,” “Relative Energy

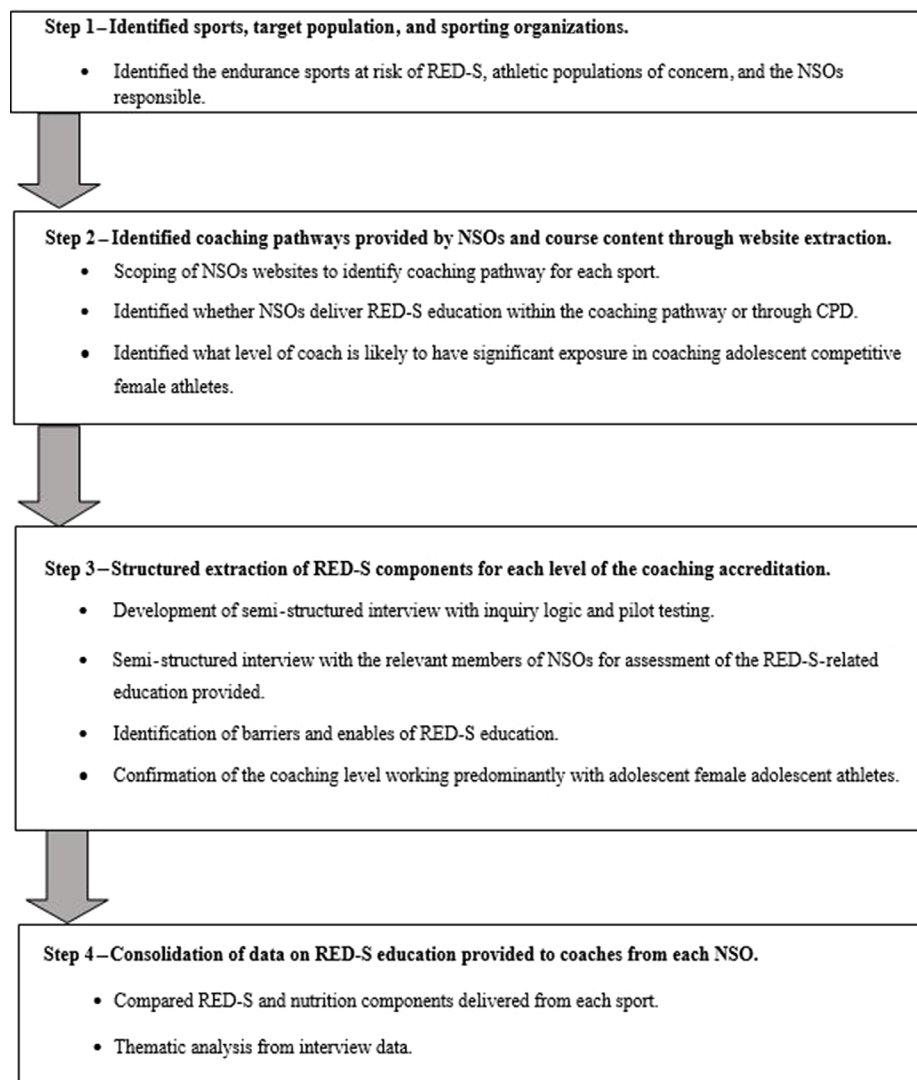


Figure 1 — Stepwise approach employed to identify all RED-S and LEA content provided by NSOs during coach accreditation programs within popular endurance sport in Australia. CPD = continuing professional development; NSOs = national sporting organizations; RED-S = Relative Energy Deficiency in Sport; LEA = low energy availability.

Deficiency in Sport (RED-S),” “risks of RED-S,” “coach education RED-S,” and “coach education on low energy availability (LEA).” Gray literature was sourced from websites of leading NSOs.

The target population included adolescent female endurance athletes—a group identified as being particularly vulnerable to RED-S (Day, Wengreen, & Heath, 2016; Logue et al., 2020). The sports identified as priority activities for the population group with the greatest risk of LEA and RED-S included athletics, swimming, cycling, triathlons, and rowing (Logue et al., 2018). Internet searches identified the Australian NSOs (key stakeholders) overseeing these sports as Athletics Australia, Cycling Australia, Swimming Australia, Rowing Australia (RA), and Triathlon Australia. Given that the education curriculum for coaching accreditation pathways varies between nations, to maintain methodological rigor, the present review was limited to the Australian coaching curriculum for the included endurance sports.

Step 2: Identified Coaching Pathways Provided by NSOs and Course Content Through Website Extraction

Initial reviews of the five NSO’s websites were conducted to collect information regarding the structure of their coach accreditation pathways. For each coaching level identified, information was categorized into the following areas: (a) education modules delivered, (b) the duration of education courses, (c) mode of delivery, (d) nutrition education, and (e) LEA/RED-Ss education. If evidence of nutrition and/or RED-S education was lacking, it was documented as “absent” for the website scope activity. The coaching level most likely to have significant exposure to adolescent female athletes was also identified and recorded where possible. If this information was not accessible, it was documented as “absent” for this activity and retrieved at the next stage of the study protocol. Data extraction and categorization were completed by one researcher and confirmed by the other two researchers on the project through discussion.

Step 3: Structured Extraction of RED-S Components for Each Level of the Coaching Accreditation

Following the initial website scoping activity, further information regarding RED-S and related education provided to coaches was collected via a semi-structured interview with a member of each NSO.

Participants. Initially, an e-mail request was sent to the five previously mentioned NSOs to seek interest and identify participants for the study. Target participants were individuals most familiar with the structure and development of coaching accreditation and professional development activities. If nutrition-related content was delivered by a third party (e.g., a sports dietitian), these individuals were also interviewed (where possible) to determine the extent of this nutrition education—specifically, components of the education related to RED-S. Prospective participants were sent a plain language statement outlining the project aims and requirements. Consent to participate was inferred via e-mail if an appointment was scheduled, as approved by the ethics board.

Semi-structured interview. A semi-structured qualitative interview design was employed, utilizing open-ended questions to aid discussions. The interviews were conducted to gain an understanding of general nutrition content and specifically, to explore how

(if at all) RED-S education was incorporated within the coach accreditation pathway. To maintain methodological rigor, the interview questions were developed following a review of relevant literature and based on an inquiry logic reflecting the aims of the investigation. Table 1 outlines the interview questions and associated inquiry logic for the semi-structured interviews.

Pilot study. A pilot interview was undertaken to test content and face validity of the interview questions. The participant was an experienced cycling coach who was asked to describe any difficulties in understanding interview questions or concerns with the interview process. Only minor amendments were made to the structure of the interview based on feedback received from the pilot interview. Specifically, this was to refocus one question to enable the participant interviewed to share their attitudes and advice regarding resources that the organization may find beneficial to support RED-S education, rather than identifying these from a list of specific materials that may be useful.

Interviews conducted. All interviews were conducted virtually (via the zoom platform) by one investigator who employed standardized prompts to obtain more information where needed (Rocco, 2003). Interviews were audio recorded with the participants’ permission and lasted between 45 and 60 min.

Step 4: Consolidation of Data on RED-S Education Provided to Coaches From Each NSO

One investigator transcribed each interview verbatim highlighting key recurring themes. Thematic content analysis was used to assess the transcripts (Bengtsson, 2016). Inductive interpretational analysis was conducted, such that themes produced were closely linked to the data set (Corbin & Strauss, 2014). To avoid bias, themes were generated on a semantic level, analyzing explicit content of the data to ensure analysis was driven by the data itself and not the views of the researcher (Braun & Clark, 2006). Themes were entered into a Microsoft Excel spreadsheet to develop concepts and compare provision of RED-S education between the NSOs involved. Any quotes extracted from interviews remain unidentifiable with regard to the NSO they are affiliated with in order to maintain confidentiality. Post analysis discussion and verification of themes were performed by all three investigators for agreement on interpretation of results.

Results and Discussion

This scoping review explored how (if at all) RED-S-specific education is currently incorporated within Australian NSO accredited coaching pathways for popular endurance sports. The results discussed are based on the extraction of evidence from the initial scoping review as well as additional information obtained from the interview process, where themes were identified. These results will help to inform future strategic activities (e.g., professional development opportunities for coaches) that promote coaches’ understanding of athlete health and performance specifically related to LEA and RED-S in female athletes.

Current Provisions of Nutrition and RED-S-Specific Education Provided by NSOs

Table 2 provides a summary of current RED-S-specific education for each NSO. Similar coaching accreditation pathways were identified across NSOs; they commenced at an entry or foundational

Table 1 Semi-Structured Interview Questions and Inquiry Logic for National Sporting Organizations

Interview questions	Inquiry logic
Section 1—Coaching accreditation pathways	
May I please confirm your role within the sporting organization and how long you have been in this role?	Identify whether the individual being interviewed is the most appropriate for the information we require.
Can you confirm the structure of the coaching accreditation pathway? And how long it takes to complete each phase within the structure?	To identify and verify the structure of the coaching pathway and confirm the time taken for completion across different coaching levels.
Is there a national curriculum that every state across Australia follows for the delivery of their coaching accreditation pathways, or does this vary across states with regards to content and who delivers the education?	To understand whether there is consistency across all states in the delivery of education provided to coaches around nutrition, health, and performance.
Can you confirm which level of coaches get significant exposure to coaching adolescent female athletes?	To identify which level of coaches is mainly working with targeted athletic population group.
Section 2—Education specific to LEA and RED-S	
Are you familiar with the term Relative Energy Deficiency in Sport (RED-S)? In your own words, can you describe it to me?	To ensure the individual is aware of the condition prior to questions being asked about RED-S. If they are not, a brief explanation will be provided. If the individual answers yes, a definition in their own words will be requested to confirm their understanding matches our definition.
Are you aware of any policies in place around RED-S within your sporting organization? If yes, what policies are these, and can you direct these to me? If you are unsure is there anyone else in the organization who may be able to provide me with this information?	To identify whether there are any policies already in place on RED-S that those working with athletes need to adhere to.
Do you have educational material within your coaching accreditation pathway on the topic of LEA and/ or RED-S or concepts that may overlap into this area (Energy expenditure from exercise, female athlete triad, eating disorders, energy costs of metabolism, under fuelling)? If YES: Can you further explain specific topics covered and how the content is delivered? Is this education consistent across the coaching curriculum? If not, can you specify how this differs across the coaching levels?	To establish whether the nutrition education provided covers LEA and RED-S within the curriculum. To also confirm what topics are covered in the curriculum and how these are delivered.
Section 3—Nutrition education	
Can you describe for me any nutrition education provided within the coaching curriculum and to what extent this area is covered across each coaching level (topics covered at each coaching level, method of delivery, who delivers the education)? If you do not know or are unsure, are you able to provide me with access to this information?	To establish whether there is any nutrition education provided by the sporting organization. Also, to understand the depth of this education and who delivers the education and the method of delivery.
If you were provided with resources to deliver as part of the educational coaching framework on the topic or LEA and RED-S, what kind of resources do you think would be most useful? (e.g., presentations, workshops, lectures, quizzes).	To get an understanding of what the sporting organization thinks are the most useful methods to deliver education to their coaches, which will help us to understand what resources are perceived as most effective in their coaching accreditation pathways.
Do you have anything more you would like to add?	Provide the individual with the opportunity to provide any further information they deem relevant.

Note. RED-S = Relative Energy Deficiency in Sport; LEA = low energy availability.

level (i.e., Level 1, introductory, developmental) with opportunities for stepwise progression (between three and five levels) to the highest accreditation level within the sport (typically associated with elite or national level athletes). All NSOs included in this review were supported by a national coach educational curriculum.

Overall, RED-S educational material was lacking in the coach accreditation pathways for four of the five NSOs (Cycling Australia, Athletics Australia, Swimming Australia, and Triathlon Australia). While these NSOs do include delivery of nutrition information as part of the coaching curriculum, this is generally confined to basic nutrition content (e.g., healthy eating guidelines, macronutrients, hydration, pre- and postexercise nutrition). Information related to the Female Athlete Triad is provided to Level 1 and 2 coaches in the Cycling Australia curriculum, but this was described as being relatively brief in nature.

In contrast, the RA coaching curriculum contains dedicated RED-S and related nutrition education in two of the four coaching accreditation levels (Table 3). Level 2 coaches receive fundamental nutrition content (major macronutrients and micronutrients), vegan and vegetarian diets for the high-performing athlete, hydration and recovery, nutrition when traveling, understanding safe methods to manipulate lean mass or fat mass, and supplementation. Level 3 coaches are provided with a more detailed analysis of the nutritional needs of elite rowers, including different challenges they may encounter when working with athletes. These include strategies to address weight manipulation (particularly in lightweight categories), in addition to case study examples of athletes experiencing LEA. These examples are designed to upskill coaches to improve identification of athletes at risk of RED-S. At the time of conducting interviews, the RA Level 4 coaching accreditation course was being revised; thus, information on this level was unavailable. RA was the

Table 2 Nutrition and RED-S-Specific Education Delivered Within the Coaching Accreditation Pathways by National Sporting Organizations

Sporting organization	Coaching levels	Coaching population group	Healthy eating guidelines	Sports nutrition	Macronutrient guidelines for sport	Pre/post training nutrition	Hydration	RED-S education
Cycling Australia	Introductory	Schools and community*	No	No	No	No	No	No
	Community	Entry-level club coach*	No	No	No	No	No	No
	Level 1	Competitive club coach*	Yes	Yes	Yes	Yes	Yes	No
	Level 2	Elite athlete coach (juniors and under 23)*	Yes	Yes	Yes	Yes	Yes	No
	Level 3	Lead national coach	No	No	No	No	No	No
Swimming Australia	Developmental	Community and recreational*	Yes	No	No	No	No	No
	Advanced developmental	Competitive and regional*	Yes	No	No	No	No	No
	Performance	Elite level	Yes	No	No	No	No	No
Athletics Australia	Level 1	Community*	No	No	No	No	No	No
	Level 2	Club level*	Yes	No	No	No	No	No
	Level 3	Performance development*	Yes	Yes	Yes	Yes	Yes	No
	Level 4	Senior elite IAAF	Yes	Yes	Yes	Yes	Yes	Yes
Triathlon Australia	Foundation	Novice/ community*	No	No	No	No	No	No
	Developmental	Recreational club level*	No	No	No	No	No	No
	Performance High performance	Competitive club* Elite level	Yes Yes	Yes Yes	Yes Yes	Yes Yes	Yes Yes	No No
Rowing Australia	Level 1	Novice coach*	No	No	No	No	No	No
	Level 2	Club/school*	Yes	Yes	Yes	Yes	Yes	Yes
	Level 3	State and junior national teams*	Yes	Yes	Yes	Yes	Yes	Yes
	Level 4	Elite high performance	N/A	N/A	N/A	N/A	N/A	N/A

Note. RED-S = Relative Energy Deficiency in Sport; IAAF = International Association of Athletics Federations.

*Coaches with exposure to adolescent athletes.

only NSO contacted who provided RED-S related content via an Accredited Sports Dietitian, which may (in part) explain the emphasis afforded to RED-S within their coaching curriculum.

The inadequacy of RED-S education in the coaching curriculum of NSOs participating in this investigation is consistent with previous reports highlighting limited coach knowledge and understanding of the condition across a variety of sports (Gastrich, Quick, Bachmann, & Moriarty, 2020; Mukherjee et al., 2016; Torres-McGehee et al., 2012). Coaches are in a unique position of influence for preventing the development of RED-S (Gastrich et al., 2020). Thus, sporting organizations have been encouraged to prioritize coach education on EA to protect the long-term health of their athletes (Gastrich et al., 2020; Mountjoy, Sundgot-Borgen, et al., 2018).

Barriers/Challenges and Facilitators

The interview process enabled the generation of themes, which were identified to be consistent across the NSOs. This helped to understand some of the challenges NSOs experience for the inclusion of education specific to RED-S for coaches of female athletes. A summary of barriers/challenges and facilitators for the inclusion and delivery of RED-S education material described by the NSOs during interviews is presented in Table 4.

Limited time and resources. Three of the five NSOs indicated time and resource challenges for inclusion of RED-S content within their coaching curriculum. Coaching courses prioritize sport-specific coaching elements and components of fitness, with some NSOs indicating they felt nutrition-related education was overlooked.

Table 3 Nutrition and RED-S-Specific Education Delivered Within the Coach Accreditation Pathway at RA

Coaching level	Nutritional education	RED-S/LEA education
Level 1	N/A	N/A
Level 2	Nutrition fundamentals Roles of major dietary macronutrients and certain micronutrients (cho, pro, fats, iron, calcium) Fundamental nutritional elements and sources from foods Vegetarian and vegan diets for the high performing athlete Pre- and postcompetition and training nutrition Hydration and recovery Pre- and postcompetition hydration schedules Sports drinks 4 R's of recovery (refuel, repair, rehydrate, and revitalize) Travel and competition Planning what and when to eat Consideration of how to overcome nutrition challenges when traveling Suggestions for pre- and postcompetition meals when traveling Body size and shape Understanding different nutritional needs of athletes based on different body sizes and shapes Understanding how to safely manipulate nutritional intake to change lean mass or fat mass Principles for energy balance for weight gain/loss Supplements Which supplements are safe for consumption? Food versus supplements (food-first approach) Provide direct information about where to find more info on supplements for athletes Supplement policy at Rowing Australia Recipes Resources for recipes for athletes and where to seek further nutrition support	Risks associated with not matching EI with EEE (e.g., poor bone health, fatigue, amenorrhea, poor recovery, increased injury, suppressed metabolic rate, poor iron status). Reasons for inadequate EA (voluntary, e.g., disordered eating, or involuntary, e.g., unaware of requirements, poor nutrition choices, difficulty in consuming enough). Possible ways to speak to athletes of concern for LEA and issues around body composition.
Level 3	Same content delivered as in the Level 2 course with additional topics covered including: Hydration Specific factors affecting how much fluid is required for each athlete based on losses and intake Risks associated with dehydration Body size and shape Assessment of body composition Ideal body composition for openweight rowers (elite) Nutrition for lightweight rowers Risks due to emphasis on body composition. Safe weight management strategies Nutrients of concern (calcium and iron) and how to address this Chronic weight management Acute weight making strategies Supplements Specific guidance for acceptable supplements across different age categories (junior, U23, senior) AIS supplement program Detailed breakdown of regulated supplements and benefits they may provide for athletic performance	Risks associated with not matching EI with EEE (e.g., poor bone health, fatigue, amenorrhea, poor recovery, increased injury, suppressed metabolic rate, poor iron status). Reasons for inadequate EA (voluntary, e.g., disordered eating, or involuntary, e.g., unaware of requirements, poor nutrition choices, difficulty in consuming enough). Possible ways to speak to athletes of concern for LEA and issues around body composition. Symptoms to look out for in athletes (e.g., weight loss, injury/illness, menstrual dysfunction, disordered eating, and lack of training adaptation). Specific concerns for lightweight rowers for LEA. Risks involved and nutrients of concern (calcium and iron).
Level 4	N/A	N/A

Note. RED-S = Relative Energy Deficiency in Sport; LEA = low energy availability; EA = energy availability; EEE = exercise energy expenditure; EI = energy intake; RA = Rowing Australia; AIS = Australian Institute of Sport.

When nutrition content was provided, it was typically delivered across a short period within an intense coach education program (one NSO reported 2 hr over a 50-hr teaching week). This is not the first study to identify time as a potential barrier for coach education. Consistent with our findings, previous research highlights formal coach education courses are often delivered over tight timelines, which may compromise the quantity and quality of content delivered, as well as coach learning development. Potentially, this results in

coaches who are inadequately equipped to support athlete health and well-being (Mallett, Trudel, Lyle, & Rynne, 2009).

Coaches preexisting RED-S knowledge. Four of the five NSOs indicated that coaches' preexisting RED-S and nutrition-related knowledge was a barrier to implementation of RED-S education within their coaching curriculum. Indeed, the only NSO to provide education on the topic also described considerable variation in coaches' baseline RED-S and nutrition knowledge as a major

Table 4 Barriers/Challenges and Facilitators Identified for the Delivery of RED-S Educational Material at National Sporting Organizations

Barriers/challenges	Excerpts from interview
Limited time and resources available	<p>“I think considering we have so many aspects to cover in coach education for athletics being such a diverse sport, there is a sense that we do not have enough time to go in to too much detail.”</p> <p>“It is challenging because [during] the coach education, they spend days on swim technique, running, bike transitions, bike maintenance. It is cramming like 3 in to 1 and nutrition has just almost been a side bar. But we do need all that other stuff as-well, so it is finding a suitable way to interweave it all.”</p> <p>“We are trying to improve our processes, which have not been optimal. Not through anyone’s fault but more due to financial and time restrictions.”</p> <p>“Level 3 is delivered face-to-face, with normally about 30–40 coaches and they get 2 hours of nutrition as part of a 10 hours day of other stuff, so it is really hard to extend the content. They come for a week and have 8–10-hour days so it’s pretty full on. You get quite high level coaches and the work in high level institutes but then you get school level coaches and people who are 75 who have no clue at all, so it is hard to put the content in with the time available.”</p>
Coaches’ preexisting RED-S knowledge	<p>“So in the level 3 there is not a section on energy availability and RED-S because sometimes I don’t even know if coaches know what carbohydrates are, so what I have tried to do is a [mixed] flavor of things that will influence energy availability throughout it.”</p> <p>“Female Athlete Triad education, It is basic, because often with a group of coaches in the room their preexisting knowledge can vary so it is difficult to detail much further.”</p> <p>“I think this is likely to be similar with RED-S where there will be a lack of basic knowledge among coaches so we will need to be able to deliver something in a way that they can understand.”</p> <p>“Those coaches with more of a sports science-based background are more likely to engage in the resources we put out to them, but I am not always sure if they read these things? They may read it, but maybe this depends if they already have preexisting knowledge on the condition, they may be more interested.”</p>
Coaches’ preexisting beliefs	<p>“Some coaches are still lacking appreciation of the health of athletes, and this is where we need more policy and structure in place. For example, we had a junior athlete who reported her previous coach set her a weight loss target of 8 kg and this was at junior level. This actually messed this athlete’s health up when she reached senior level.”</p> <p>“Equally there is the challenge of addressing coaches’ upheld beliefs and often coaches can be reluctant to change their coaching styles or behaviors from what they have known.”</p> <p>“In the coach education there is no discussion about the specifics of a female athlete. Most of the coaches are men. From what I have seen, aged 50 years and over who do not want to know or talk about it, have never been educated about it, and it’s easier for them to put their head in the sand and say its women’s issues and ignore it rather than address the issue.”</p> <p>“Coaches respond well to other coaches. They don’t respond well to being lectured by scientists unfortunately.”</p> <p>“Alternatively, coaches may have set ways in their coaching style so [they] do not want to engage or change.”</p>
Facilitators	
Organization enthusiasm for support	<p>“Anything we can get from the experts that we can share with our coaches, or have you come and share with our coaches we just love it, we just love anything that makes our coaches have a broader education and understanding. It would just be fantastic. Especially to be able to deliver detailed education on such an important topic such as RED-S, it would be so valuable to our coaches.”</p> <p>“It would be awesome to have the benefit of the knowledge from experts in this area and we could incorporate it into the coaching platform for the benefit of our coaches and to better educate them on this important topic.”</p> <p>“It would be great if there was an educational resource that you may be able to produce that could help us to further develop our coach education curriculum on this important area. We have been looking to do something about RED-S and it has come up in discussion a few times.”</p> <p>“This is a very topical area at the moment and relevant to where we are trying to improve our processes. We are embryonic in this at the moment, but any external support is always welcomed.”</p> <p>“We have such a range of people involved in the sport coaching; it is an area that is of interest across a whole raft. A range of different resources is always useful.”</p>
Facilitator experience	<p>“When I teach it, I diversify, I reference this book, Stacy Sims. Whereas that might not be the case with someone who presents in New South Wales. It depends on the background of the presenter.”</p>

Note. RED-S = Relative Energy Deficiency in Sport.

challenge to the provision of appropriate information. Consistent with our findings, previous work has identified coaches as having limited knowledge on these topics, with some prioritizing strength and conditioning specialists as their go-to resource for nutrition advice as opposed to a registered sports dietitian (Torres-McGehee et al., 2012).

Coaches preexisting body composition beliefs. Four of the five NSOs indicated that preexisting beliefs and behaviors of coaches with regard to body composition and EA were challenges for the inclusion of RED-S content within their coaching curriculum.

Previous research suggests that coaches may have inappropriate perceptions regarding the relationship between leanness, the acute effects of LEA, and the long-term health of female athletes (Lassiter & Watt, 2007; Mukherjee et al., 2016). Unfortunately, several high-profile case studies have highlighted the direct outcomes of toxic coach and athlete relationships that manifest when performance is prioritized over athlete health and well-being (Ackerman et al., 2020; McMahan & Penney, 2013).

In a 2013 investigation exploring the experiences of three Australian female swimmers, participants felt coaches viewed their

bodies as an object for manipulation, with strict weighing protocols employed in pursuit of lightness (McMahon & Penney, 2013). The current results suggest several NSOs are concerned that some nationally accredited coaches continue to employ training strategies exclusively designed to manipulate an athlete's physique— independent of performance. While it is assumed that coaches are not intentionally aiming to harm athlete health, there appears to be an imperative for NSOs to provide more support to ensure coaches are not indirectly contributing to athletes developing RED-S (Heffner, Ogles, Gold, Marsden, & Johnson, 2003).

The language and behavior adopted by coaches when working with athletes can affect self-esteem, physical, and mental health (Ackerman et al., 2020; Coppola, Ward, & Freysinger, 2014). It is important that coaches bestow a nurturing environment, which promotes both the physical and mental health of athletes. Indeed, this premise has been incorporated into several national consensus statements (Desbrow et al., 2014; Wells et al., 2020). Gymnastics Australia is the first NSO to develop guidelines for appropriate language and behavior when working with athletes in an attempt to better support gymnasts' health and well-being (Gymnastics Australia, 2019). Adoption of similar guidelines across the broader network of NSOs may be a potential strategy to ensure coaches working with adolescent female athletes facilitate behaviors that ultimately reduce the risk of their athletes developing RED-S and associated health conditions.

Facilitators. All five organizations expressed enthusiasm to include educational material on the topic of RED-S within their coaching education curriculum. This interest was verified by several NSOs undertaking research projects to further investigate female athlete physiology and/or employing individuals to develop RED-S education resources. Despite these recent changes, several NSOs acknowledged these as embryonic attempts to address RED-S within the context of their coach accreditation programs and recognized the need for further support.

Limitations and Future Research

The present study targeted NSOs in Australia, with interview data only collected from a selected number of individuals. As such, findings from this study may not be generalizable to other sporting organizations or in international contexts. We also did not collect information directly from coaches to identify their experiences and/or concerns regarding female athletes and issues developed in association with RED-S. Furthermore, we were unable to determine if other factors (e.g., gender, age, experience of coaches, etc.) influence coaches and NSO's appreciation (and seriousness) of RED-S and need for education. Hence, there are potential opportunities for future research to explore these factors and gain a better understanding of coaches' experience and/or concerns regarding RED-S.

Summary and Conclusion

In summary, this scoping review illustrates the lack of RED-S-specific education material that is currently incorporated into the coach accreditation pathways of NSOs for popular endurance sports in Australia. A lack of time and resources, coaches' preexisting knowledge, and beliefs were identified as barriers for implementation of education on RED-S. However, NSO staff appear to be enthusiastic with respect to pedagogical change, appreciating the need to incorporate RED-S content into the curriculum. Capitalizing on this opportunity to enhance coaches' knowledge and awareness

of RED-S may play a pivotal role in preventing, detecting, and managing adolescent female athletes at risk of RED-S.

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