

A review exploring coach knowledge, attitudes/beliefs and behaviours towards low energy availability in athletes

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Abstract

Coaches are important figures of influence with potential to create environments that influence athlete health and performance outcomes. Ideally, coaches provide supportive environments that lead to performance optimisation and long-term health. Coaches who employ language and behaviours that overemphasise body composition and/or provide misinformed nutrition advice may predispose athletes to low energy availability (LEA) and the associated health consequences. Having a clear understanding of current knowledge, attitudes and beliefs of coaches with regard to LEA is required to guide future coach education/support initiatives to optimise athlete health and performance. Thus, the aim of this investigation was to systematically review published literature regarding coach knowledge, attitudes/beliefs and behaviours of LEA.

Data from 20 eligible studies was extracted into predetermined categories according to coach 'knowledge'; 'attitudes/beliefs'; and 'behaviours' regarding LEA/Relative Energy Deficiency in Sport/Female Athlete Triad and/or eating disorders and/or disordered eating. Any single study could provide outcomes to inform one or multiple of these categories. The majority of results were drawn from studies conducted prior to LEA being defined as a concern for athlete health, which limited our understanding of the contemporary knowledge, attitudes/beliefs and behaviours of coaches on this important issue. That said, indications of gaps in coach knowledge and the employment of inappropriate attitudes/beliefs and behaviours regarding issues associated with LEA were evident. An opportunity exists for key stakeholders to develop comprehensive coach education frameworks, which equip coaches with the adequate capability, opportunity and motivation to support athlete health and avoid the consequences of LEA.

Keywords

Eating disorders, female athlete triad, health, physique, relative energy deficiency, weight management

Introduction

In individuals with high energy expenditures (e.g. competitive athletes, dancers, recreational athletes), low energy availability (LEA) occurs when energy intake (EI) is insufficient to meet biological requirements.¹ LEA is the underpinning factor that leads to the Female Athlete Triad (FAT) and Relative Energy Deficiency in Sport (RED-S),^{1,2} two concepts defining the health implications of prolonged periods or repeated acute bouts of insufficient EI.^{1,2} LEA has been extensively reported and described in female athletes as part of the FAT, specifically in relation to impacts on bone health and menstrual function.^{2–4} In 2014, the International Olympic Committee published an updated consensus statement recognizing that LEA affects (1) cohorts other than elite/competitive female athletes (e.g. males and recreational athletes) and (2) these individuals were at risk of potential health and performance implications

that go beyond those previously described in the FAT.¹ Accordingly, the new term RED-S was adopted, encompassing the full scope of symptomology.^{1,3,5,6}

The causes of LEA are manifold^{6,7} and can be influenced by socio-cultural, demographic, environmental, biological, psychological, and behavioural factors.^{7–9} LEA may

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develop unintentionally through poor knowledge/awareness of required EI's and/or due to reduced opportunities for food consumption around training/exercise.^{7,10} Additionally, an increase in training may result in appetite suppression and challenges in consuming sufficient calories.^{7,10,11} In contrast, disordered eating and/or eating disorders (DE/ED's), underpinned by a psychopathology can either precede or be the result of LEA.^{8,11} Athletes are identified to be at an increased risk of developing an eating pathology, which can be influenced by pressures relating to body weight, shape, size and/or appearance as they attempt to achieve the sport-specific and/or society body ideals perpetuated by media, social media, teammates, parents and/or coaches.^{12,13} Furthermore, some intrinsic characteristics of successful athletic performance are similar to factors predisposing individuals to DE/ED risk (e.g. perfectionistic, competitive, and high levels of motivation).^{11,14}

Despite the increased recognition of the health implications associated with LEA, many athletes and coaches remain unaware of this concept and/or the associated consequences.¹⁵⁻¹⁷ Coaches have continuous engagement with athletes, hence can play a purposeful role to mitigate risks, detect and support the management of LEA and associated health complications.^{11,17-19} Ideally, coaches should provide supportive environments, encouraging exercise and eating behaviours that lead to performance optimisation and long-term health.^{11,13,19,20} However, some coaches have been identified to prioritise 'high performance' at the cost of long-term health and wellbeing of their athletes.^{17,18,21,22} Furthermore, research suggests that while a proportion of coaches collaborate with other health-care practitioners to support athlete health, others fail to appreciate the importance of certain factors (e.g. adequate fuelling for athletes) to mitigate the risks of LEA.^{7,13,22} Importantly, coaches who employ language and behaviours that overemphasise body composition and/or provide misinformed nutrition advice may predispose athletes to significant harm.^{7,8,22,23}

Given the potential deleterious implications LEA can have on an athlete's health and performance,^{1,8} sporting organisations are starting to acknowledge the importance of providing a nurturing environment to ensure the long-term health of athletes participating in their sport.^{19,24} To assist sporting organisations in achieving these goals, it is important that figures of authority and influence (e.g. coaches) are appropriately educated and supported.^{18,19} Since coaches play an important role in an athlete's performance trajectory, it is crucial there is a clear understanding of their current knowledge regarding LEA. To date this has not been consolidated in a review of existing evidence.

The aim of this review is to summarise published literature regarding coach knowledge, attitudes/beliefs and behaviours towards LEA in athletes. This information will inform future coach education/support initiatives to optimise athlete health and performance.

Methods

Literature search and review structure

This review was conducted following the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines.²⁵ While a systematic review was the initial intention of the study, following article capture it became apparent that study designs and outcomes were too heterogeneous to consolidate using this approach. As such the results and discussion have been presented in the form of a narrative review.

Data sourcing and search strategy

Four electronic databases were used to ensure all relevant studies were sourced. Databases included PubMed (MEDLINE), Scopus, SPORTDiscus via EBSCO and Web of Science. The following filters were applied: Humans; English. Two separate searches were undertaken. The first search focused on LEA, RED-S and FAT and included the terms 'coach*' AND 'low energy availability' OR 'female athlete triad' OR 'relative energy deficiency in sport' OR 'RED-S' OR 'LEA'. To ensure all LEA associated information was captured, the second search focused on DE/ED'S and included the terms 'coach*' AND 'eating disorders' OR 'disordered eating'. The star symbol (*) was used to capture derivatives (by suffixation) of the search terms (e.g. coaches). Reference lists of key studies were searched manually to retrieve any further relevant literature that had not been identified from the initial search strategy. The final database search was carried out in September 2021. No year restrictions were applied.

Study eligibility and selection

Studies had to meet the following inclusion criteria: (i) manuscripts written in English; (ii) original quantitative or qualitative research articles; (iii) coach knowledge, attitudes/beliefs and/or behaviours of LEA/RED-S/FAT or ED's/DE were assessed. Exclusion criteria included: (i) review articles or those not considered original research; (ii) unpublished papers; (iii) abstracts only papers/conference proceedings; (iv) reports.

Identified literature was initially screened by title and abstract to determine relevance of the subject matter. Remaining studies underwent full text screening by one researcher (JH) to assess potential suitability. For ambiguous cases, two further independent researchers (BD & CI) confirmed inclusion or exclusion of studies. A PRISMA flow diagram of the review process is presented in Figure 1. Forty-three papers were excluded following full text review. For full details of reasons for exclusion, see Supplemental Tables S1 (LEA/FAT/RED-S) and S2 (ED's/DE).

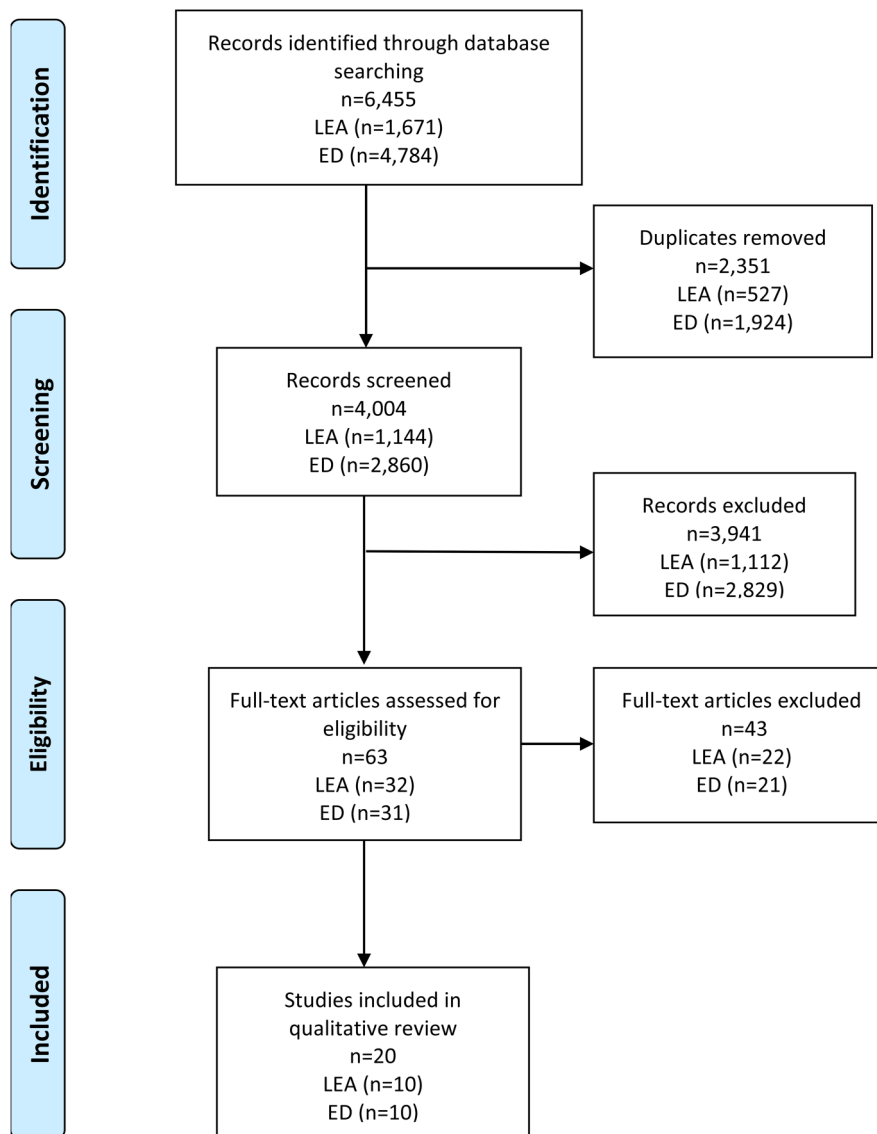


Figure 1. PRISMA flowchart of the review process for coach knowledge, attitudes/beliefs and behaviours on LEA/RED-S/FAT or ED/DE.

Data synthesis

Data from the 20 eligible studies was extracted into predetermined categories according to coach ‘knowledge’; ‘attitudes/beliefs’; and ‘behaviours’ regarding LEA/ RED-S/FAT and/or ED’s/DE. Any single study could provide outcomes to inform one or multiple of these categories. Eligible studies were also considered based on their publication date, location, and the athletic pursuit. Table 1 presents the number of included studies relating to LEA/FAT/RED-S and ED/DE, which contribute data to coach knowledge, attitudes/beliefs and/or behaviours.

Results

Ten studies explored coach knowledge, attitudes/beliefs, and behaviours in the context of the FAT.^{17,21,26–33} A

further 10 studies explored coach knowledge, attitudes, beliefs and/or behaviours of ED/DE.^{34–43} To date only one study considered LEA in the context of the RED-S model.³³ A chronological timeline of the 20 included investigations is presented in Figure 2. Most investigations were undertaken in the USA ($n=14$) with the remaining in Europe ($n=4$), Canada ($n=1$) and Singapore ($n=1$). Coaches sampled in the investigations included those from ‘multi-sport’ settings, gymnastics, cross-country running, athletics, dance, tennis and aesthetic/weight class activities. Coaching experience ranged from 4 months to 45 years and in those studies where information on the age of coaches was available, this ranged from 24 to 69 years. Summary of knowledge, attitudes/beliefs and behaviours relating to LEA extracted from studies specific to the FAT/RED-S and ED/DE are reported in Tables 2 and 3, respectively.

Coach knowledge relating to LEA extracted from studies specific to FAT/RED-S and ED/DE

Considerable heterogeneity exists in methodological approaches employed to assess coach knowledge. Typically, coach knowledge was assessed through questionnaires using a mixture of categorical and open-ended responses and involved between 8 and 37 items. Five of the FAT studies reported that >80% of participating coaches were unable to identify all components of the model,^{17,21,27,28,32} or recognise common signs and symptoms.^{28,32} Other studies suggest a greater proportion (43–73%) coaches working in settings with more elite athletes (e.g. Division 1) were able to identify all components of the FAT.^{26,30,31} To date only one study has explored coaches' knowledge (in collegiate cross-country coaches) of LEA in the context of RED-S (incorporated in a FAT study).³³ This study employed a small number of questions ($n=2$ specific to FAT, $n=3$ specific to RED-S) with results indicating average scores of >65% for knowledge of both FAT and RED-S.³³

Five of the ten studies explored coach knowledge of ED/DE. Four of these adopted the same assessment tool (or a modified version) developed by Turk et al.,³⁴ which assessed five areas; (1) aetiology; (2) identifying signs

and symptoms; (3) risk factors; (4) prevention and education; (5) management and treatment.^{34,35,38,43} Scores for each domain ranged from 72% to 80% for aetiology; 60% to 87% for identifying signs and symptoms; 72% to 92% for risk factors; 64% to 81% prevention; and 64% to 77% for management and treatment.

The remaining study consisted of an educational intervention, incorporating educational workshops, seminars and self-study tasks related to nutrition, weight regulation and ED aiming to enhance coach knowledge and management of ED in high school athletes. Results demonstrated an improvement in knowledge with index scores increasing from 21.7 to 35 (possible total score of 55) among coaches in the intervention group.⁴¹

Coach knowledge of menstrual function

Six studies investigated elements of coach knowledge regarding menstrual function.^{21,26,27,29,32,36} Coaches understanding of menstrual irregularities being a warning sign of LEA; hence the risk posed to athlete health, appears to be highly variable (28²⁶–74%²¹). Three studies questioned coaches on associations between menstrual function and bone health (e.g. stress fractures, osteoporosis).^{21,26,32} Coaches' knowledge of this appears to be dependent on their level/experience, with greater knowledge observed in studies conducted with Division 1 coaches (69%)²⁶ than those investigating high school coaches (20²¹–31%³²).

Table 1. Number of studies contributing to each pre-determined category according to coach knowledge, attitudes/beliefs and behaviours.

	Knowledge	Attitudes/ Beliefs	Behaviours
LEA (FAT/RED-S) ($n = 10$)	10	6	7
ED/DE ($n = 10$)	7	5	6

Note: Studies could contribute information/data to multiple categories. LEA: low energy availability; FAT: female athlete triad; RED-S: relative energy deficiency in sport; ED/DE: eating disorders and/or disordered eating.

Coach attitudes/beliefs and behaviours relating to LEA extracted from studies specific to the FAT/RED-S and ED/DE

Thirteen studies assessed coach attitudes, beliefs and/or behaviours.^{17,21,26–29,32,36,37,39,40,42,43} The majority adopted quantitative assessment tools ($n = 11$),^{17,21,26–29,32,36,37,42,43} while two employed a qualitative approach.^{39,40} Three themes were identified including, menstrual function,

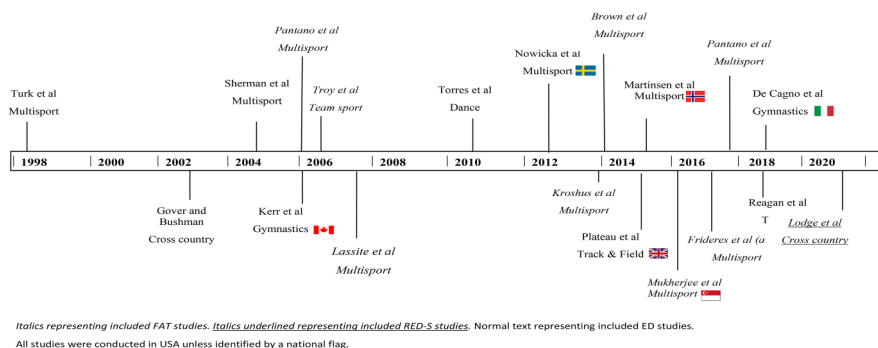


Figure 2. Chronological timeline of studies investigating coach knowledge, attitudes/beliefs and behaviours on LEA/RED-S/FAT or ED/DE, and their country of origin.

physique/weight management practices and the coach–athlete relationship.

Attitudes/beliefs and behaviours towards menstrual function

Coaches' attitudes/beliefs towards menstrual function are variable. Six studies reported that >50% of coaches had some awareness that menstrual dysfunction/amenorrhea is an undesirable consequence of engaging in high volume/intensity training.^{17,21,26,29,32,36} Despite this, a considerable proportion of coaches (19–42%) expressed little concern towards the associated health implications that may occur because of menstrual irregularities and/or amenorrhea.^{21,26,30,32,33,36,40}

Coaches' engagement in conversations related to menstrual function also varies.^{17,21,26,27,32,42} One study reported that <20% of coaches discuss issues relating to menstrual function with their athletes.²⁷ Other studies identified that a greater proportion of coaches (42–72%) expressed feeling confident and comfortable discussing these issues,^{17,21,26,32,42} with this more apparent among female (34–72%) compared to male (20–42%) coaches.^{17,32}

Attitudes/beliefs and behaviours towards physique and weight management

Six studies described coach attitudes/beliefs and behaviours towards physique and/or weight management practices.^{17,26,28,29,37,40} Even at the elite level (e.g. National/Division 1), coaches demonstrated highly variable (36–82%) behaviours in relation to weighing and/or monitoring body composition of athletes.^{26,37,40} Furthermore, some inconsistencies were identified between the behaviours that coaches employ themselves compared to those conducted by colleagues. For example, in one study of gymnastics coaches, none of the 28 respondents claimed to implement regular weighing, while 82% said that other coaches engaged in this practice.³⁷

Attitudes towards physique and/or body composition were examined in four investigations.^{17,28,29,37} All studies suggested a large proportion of coaches (54³⁷–76%¹⁷) emphasise the importance of low body fat, 'leanness' and reductions in weight within the coaching environment.^{17,28,29,37} In addition, some coaches agreed that it is appropriate for them to provide advice/strategies to reduce body fat and manipulate weight/physique.^{28,29}

Attitudes/beliefs and behaviours relating to coach–athlete relationship

Two qualitative studies identified important aspects of the coach–athlete relationship that align with some of the

quantified results relating to menstrual function and/or physique/weight management previously described.^{39,40} Three types of coach–athlete relationships were reported, which may have an influence on an athlete's risk of developing LEA and/or DE/ED. These were described as 'supportive',⁴⁰ 'avoidant'⁴⁰ or 'confrontational'.^{39,40} Supportive relationships comprised of strong and open coach–athlete relationships, where discussions relating to issues outside of sporting performance (e.g. health related) were normalised. Avoidant relationships were recognised to being driven by the coach, the athlete or a combination of both and frequently involved conflict between the coach and athlete.⁴⁰ Avoidant coaches demonstrated an aversion to recognise DE behaviours or denied the presence posing alternative explanations for abnormal behaviours.⁴⁰ Equally, avoidant athletes demonstrated denial of their own DE behaviours and/or LEA symptoms.^{39,40} The confrontational approach was directed by the coach, employing scare tactics and strict rules and/or targets regarding weight and/or training.^{39,40} Confrontational approaches employed inappropriate choices of language when speaking to athletes on issues related to LEA (e.g. DE and dieting/nutrition).³⁹

Discussion

This review considered the existing literature investigating coach knowledge, attitudes/beliefs and behaviours towards LEA. The evidence included in this review has been drawn from a limited number of studies, with the majority conducted prior to LEA being defined as a concern for athletes. Overall, the results indicate that coaches' knowledge, attitudes/beliefs and behaviours are highly variable and may be influenced by cultural pressures, coach education/experience and/or gender. Coach education initiatives are needed, which may have the potential to mitigate risks of LEA in athletes and the associated health implications.

Coach knowledge of LEA extracted from studies specific to FAT/RED-S and ED/DE

Coach knowledge of LEA has predominantly been assessed in alignment with older concepts (e.g. FAT); only one study in this review explored knowledge of RED-S.³³ Nonetheless, based on the included studies, findings from this review demonstrate that coaches knowledge of LEA and their ability to identify potential signs and symptoms are limited. There are some indications that coaches training elite athletes (Division 1/National level) possess greater knowledge of LEA and menstrual dysfunction/amenorrhea (specifically the risks to bone health),^{26,30,31} than coaches working with developing athletes (high school).³² This may reflect greater exposure to coach education and/or knowledge developed through coaching experience. To date, only one investigation has explored coaches knowledge of LEA in

Table 2. Coach knowledge, attitudes/beliefs and behaviours relating to LEA extracted from studies specific to the FAT/RED-S ($n = 10$).

Study (ref)	Sample	Sport coached	Coach experience/ Education	Intervention	Coach knowledge, confidence and education	Coach attitudes/beliefs	Coach behaviours
Pantano et al. (2006) USA	$n = 91$ Male = 45% ($n = 41$) Female = 55% ($n = 50$) Div 1 college coaches	Multisport	45% had 16 years coaching experience. 39% of female coaches aged 25–35 Male coaches age not disclosed	Questionnaire: Knowledge, perceptions (attitude) and behaviours regarding the FAT.	43% correctly identified all 3 components of the FAT. 57% of coaches with a 'high level' of FAT knowledge had different perceptions/ attitudes and better able to recognise signs/symptoms on the FAT ($p = 0.001$) compared to coaches with 'low knowledge'. 44% of coaches did not know amenorrhoea is a symptom of the FAT. 28% of coaches did not know the consequences of amenorrhoea; 69% stated stress fractures as a consequence, 8% said improved athletic performance.	24% believed irregular menstruation is a 'normal' consequence of exercise, and 4% stated they 'did not know'.	43% assess body fat levels of athletes. 36% never speak to athletes about menstrual function. 40% with 'high level of knowledge' failed to incorporate strategies for intervention.
Troy et al. (2006) USA	$n = 240$ Health practitioners ($n = 203$) Coaches ($n = 37$) High school/college coaches	Team sports	Range of 1–32 years coaching experience	Questionnaire: Knowledge of the FAT.	8% correctly identified all 3 components of the FAT.		31% speak to athletes about DE concerns. 84% never speak to athletes about menstrual function.

(continued)

Table 2. (continued)

Study (ref)	Sample	Sport coached	Coach experience/ Education	Intervention	Coach knowledge, confidence and education	Coach attitudes/beliefs	Coach behaviours
Lassiter et al. (2007) USA	n = 64 Male 44% (n = 22) Female 56% (n = 34) PE sports coaches	Multisport	Senior and graduate Physical Education coaches – newly qualified 25% (n = 15) had 4–11 months experience 20% (n = 12) had 1–4 years of experience 10% (n = 6) had >5 years' experience as a sports coach	Questionnaire: Knowledge, attitudes, skills and behaviours regarding FAT.	7% correctly identified all 3 components of the FAT. 26% recognised amenorrhoea as a component of FAT. 5% correctly identified 12 signs/symptoms of FAT. 67% identified at least half of the signs/symptoms. 46% correctly answered all females who are physically active are at risk of the FAT. 92% accurately identified ED's as a risk factor for the FAT. Education: 11% reported of specialised training on the FAT.	Agreement was indicated on a 5-point scale (1 = strongly agree, 5 = strongly disagree). Reported as Means (SD) An average score of 2.98 (1.24) in response to the statement 'I feel comfortable speaking to athletes about the FAT'. An average score of 1.84 (1.10) in response to the statement 'I would be comfortable talking to athletes that I coach about the FAT if I had more knowledge'.	Agreement was indicated on a 5-point scale (1 = strongly agree, 5 = strongly disagree). Reported as Means (SD) An average score of 2.98 (1.24) in response to the statement 'I give athletes that I coach advice/recommendations about their weight'.

(continued)

Table 2. (continued)

Study (ref)	Sample	Sport coached	Coach experience/ Education	Intervention	Coach knowledge, confidence and education	Coach attitudes/beliefs	Coach behaviours
Kroshus et al. (2014) USA	n = 227 Male 39% (n = 88) Female 61% (n = 138) High school coaches	Multisport:	Average of 10 years coaching experience Average age of 38.5 years	Electronic survey: Knowledge, communication, management and attitudes towards the FAT.	23% with a 'high level' of FAT knowledge had different perceptions/attitudes and better able to recognise signs/symptoms of the FAT ($p = 0.001$) compared to coaches with 'low knowledge'. Knowledge specific to FAT risks: Average scores of 3.68 (0.54) for low bone density, 3.16 (0.88) for menstrual dysfunction, 3.27 (0.71) for LEA. Mean scores are based on a four-point scale, ranging from 1 (not at all serious) to 4 (very serious). Education: 87% thought DE policies would be valuable. 88% reported pre participation questionnaire on DE, bone health and menstrual irregularity would be useful.	42% reported amenorrhea as 'normal' but should be assessed after 3–6 months, 13% thought it was 'not normal but not harmful', 1% thought it was 'normal and not serious'. Mean scores are based on a five-point scale, ranging from 1 (never) to 5 (always). An average score of 2.26 (0.87) was reported for coaches believing irregular menstruation is a sign the athlete is in peak competitive shape. An average score of 2.33 (0.95) was reported for coaches believing there is no effect on bone health with delayed onset of menstruation.	Mean scores are based on a five-point scale, ranging from 1 (never) to 5 (always). An average score of 2.45 (1.10) was reported for coaches communicating with athletes on strategies to reduce body fat. A. average score of 2.90 (1.16) was reported for coaches communicating with athletes about eliminating certain foods.

(continued)

Table 2. (continued)

Study (ref)	Sample	Sport coached	Coach experience/ Education	Intervention	Coach knowledge, confidence and education	Coach attitudes/beliefs	Coach behaviours
Brown et al. (2014) USA	n = 10 High school coaches	Multisport:	Not disclosed	Survey: Knowledge, awareness, interventions for the FAT.	1% correctly identified all 3 components of the FAT. 10% recognised the relationship between LEA and menstrual irregularities. 20% knew osteoporosis was a possible consequence of menstrual irregularities. 40% did not know any health consequences of menstrual irregularity. 40% did not know of any treatments for menstrual irregularities. Education: 50% reported a lack of time, 40% lack of education, 10% lack of triad resources as barriers to educating their athletes on the FAT.	30% thought menstrual irregularity is 'normal' in athletes.	40% never speak to athletes about menstruation.

(continued)

Table 2. (continued)

Study (ref)	Sample	Sport coached	Coach experience/ Education	Intervention	Coach knowledge, confidence and education	Coach attitudes/beliefs	Coach behaviours
Frideres et al. (2016a) characteristics USA	n = 472 Male 36% (n = 170) Female 64% (n = 302) Div I NCAA coaches	Multisport:	Average of 14.5 years coaching experience Average age of 36.8 years	Questionnaire: Knowledge, confidence and education provision on the FAT.	58% of female coaches could identify the FAT components. 60% of male coaches could identify the FAT components. 68% of females were aware of prevention and intervention strategies. 69% of males were aware of prevention and intervention strategies. Significant difference between confidence in knowledge between those receiving training on the DE component of the FAT (79% compared to 68%, $p = <0.001$)		

(continued)

Table 2. (continued)

Study (ref)	Sample	Sport coached	Coach experience/ Education	Intervention	Coach knowledge, confidence and education	Coach attitudes/beliefs	Coach behaviours
Frideres et al. (2016b) sport USA	n = 309 Male 38% Female 62% Div I NCAA coaches	Multisport	55% has a Master's degree or higher. 40% head coaches 50% assistant coaches 2% graduate coaches Average 15.1 years' experience Average age of 36.9 years	Questionnaire: Knowledge/ confidence in knowledge/ education provision on FAT.	Knowledge scores based on type of sport coached (mean %) Scoring (n = 28) 72.09%, Low body weight (n = 84) 76.31% Fitted clothing (n = 81) 71.91% Other (n = 116) 68.61% Identification of the FAT (mean %) Scoring (n = 28) 65.18% Low body weight (n = 84) 72.32% Fitted clothing (n = 81) 68.36% Other (n = 116) 50.22% Confidence levels on knowledge Scoring (n = 28) 75.25% Low body weight (n = 84) 77.18% Fitted clothing (n = 81) 71.80% Other (n = 116) 66.18%		

(continued)

Table 2. (continued)

Study (ref)	Sample	Sport coached	Coach experience/ Education	Intervention	Coach knowledge, confidence and education	Coach attitudes/beliefs	Coach behaviours
Mukherjee et al. (2016) Singapore	n = 106 Males 76% (n = 81) Females 24% (n = 25) Level 1–3 School, individual and team sport coaches	Multisport	35% level 1 coaches 30% level 2 coaches 35% level 3 coaches 58% (n = 62) ≤5 years' experience 40% 6–10 years' experience 2% unknown 22% (n = 23) had a diploma or degree in sports science/physical education 63% aged ≤25–35 34% aged 36–55 4% aged ≥ 56	Survey: Perceptions, awareness and knowledge of the FAT.	89% of coaches were unable to identify 1 of the FAT components. 11% stated they could correctly identify all 3 components of the FAT yet only 2% correctly identified all components. 53% of male and 40% female coaches correctly answered that females acquire most of their bone mass during adolescence. 68% of coaches were unaware females have a higher chance of bone mass loss.	65% agreed/ strongly agreed that low body fat is extremely important for sports performance. 76% agreed/ strongly agreed that ideal body weight and leanness should be emphasised to athletes. 38% believed menstrual irregularity to be a 'normal' outcome of sports participation. 72% of female coaches and 42% of male coaches were comfortable speaking with female athletes about menstrual function.	28% were aware of athletes eating habits.
Pantano et al. (2017) USA	n = 123 Male = 52% (64) Female = 48% (59) High school coaches	Multisport	Average 6–10 years coaching experience 55% aged ≤25–35 39% aged 36–55 6% aged ≥ 56	Questionnaire: Knowledge, attitudes and behaviours on the FAT.	14% correctly identified all 3 components of the FAT. >85% said they would not know how to recognise the signs/ symptoms of the FAT. 69% did not know stress fractures are associated with menstrual dysfunctions.	39% believed menstrual irregularity to be a 'normal' outcome of sports participation. 83% felt comfortable to ask questions about DE behaviours 54% felt comfortable in talking to athletes about menstruation (34% of females, 20% males).	52% noticed DE behaviours in athletes. 40% asked questions about abnormal eating patterns. 86% did not assess menstrual function even if they were suspicious of a problem.

(continued)

Table 2. (continued)

Study (ref)	Sample	Sport coached	Coach experience/ Education	Intervention	Coach knowledge, confidence and education	Coach attitudes/beliefs	Coach behaviours
Lodge et al. (2021) USA	n = 55 Div I NCAA Coaches Average 11 years' experience	Cross country	Average age of 36 years Average 11.8 years coaching experience 15% (n = 27) had a related academic area of study	Questionnaire: Knowledge and confidence in knowledge of the FAT and RED-S.	Knowledge scores specific to FAT: 66.70% Knowledge scores specific to RED-S: 70.93% FAT specific impact factor (combination of knowledge and confidence): 68% RED-S specific impact factor (combination of knowledge and confidence): 64%		

Table 3. Coach knowledge, attitudes/ beliefs and behaviours related to LEA extracted from studies specific to ED'S/DE (n = 10).

Study (ref)	Sample	Sport coached	Coach experience/ education	Intervention	Coach knowledge and education	Coach attitudes/beliefs	Coach behaviours
Turk et al. (1998) USA	n = 138 Males 70% (n = 96) Females 29% (n = 41) NCAA Div I coaches	Multisport	Average 13.3 years coaching experience (range of 1-45 years)	Questionnaire: Knowledge and confidence on ED's.	Total ED knowledge score 73.4%. Subcategory knowledge results: Aetiology 74% Signs and symptoms 74% Treatment 71% Risk factors 80% Prevention and education 69% Education: 37% have mandatory ED/DE programs within the athletic department. 38% reported literature to be the most readily available educational resource available from the athletic department. 90% of coaches scored 70% for ED knowledge. Subcategory knowledge results: Aetiology 80% Signs and symptoms 87% Treatment 77% Risk factors 92% Prevention and education 81%		
Govero & Bushmas (2003) USA	n = 61 Male 63% (n = 38) Female 37% (n = 22) NCAA Div I coaches	Cross Country	Average 15.1 years coaching experience (range 1-42 years) 82% (n = 50) head coaches 18% (n = 11) assistant coaches	Questionnaire: Knowledge and confidence on ED's.			

(continued)

Table 3. (continued)

Study (ref)	Sample	Sport coached	Coach experience/ education	Intervention	Coach knowledge and education	Coach attitudes/beliefs	Coach behaviours
Sherman et al. (2005) USA	n = 2894 Male 43.3% (n = 1253) Female 56.7% (n = 1640) NCAA Div 1,2, 3 coaches	Multi-sport	84% head coaches Ages/ years' experience not disclosed	Questionnaire: Attitudes, beliefs and behaviours towards DE.		37% believed amenorrhea as 'normal', 15% said it is 'normal' but should be assessed, 48% said it is 'not normal'. Coaches rated excessive exercise (3.05), undereating (3.15), weighting multiple times a day (3.08), self-induced vomiting (3.90), laxative abuse (3.83 and diuretic abuse (3.77) to have serious health implications. Mean scores reflect ratings on a 4-point scale (1 = 'not at all serious' to 4 = 'very serious').	23% indicated they would be aware of athletes having missed 3 consecutive menstrual cycles. Coaches reported ED symptoms (56.8%) were most often used for identification.
Kerr et al. (2006) Canada	n = 28 Provincial/ National level	Gymnastics	Not disclosed	Survey: Attitudes and beliefs towards ED's and weight control methods.			82% reported frequent weighing occurs in the gymnastic community. 64% stated other coaches keep private records of weight. 25% of coaches record daily food intake. 54% determine whether an athlete needs to lose weight by visual appearance. 75% claimed other coaches assess body fat percentage.

(continued)

Table 3. (continued)

Study (ref)	Sample	Sport coached	Coach experience/ education	Intervention	Coach knowledge and education	Coach attitudes/beliefs	Coach behaviours
Torres et al. (2011) USA	n = 44 NCAA Div 1, 2, 3 coaches	Dance	Not disclosed	Questionnaire: Knowledge on ED's.	Total ED knowledge score 72% Subcategory knowledge results: Aetiology 72% Signs and symptoms 67% Treatment 77% Risk factors 72% Prevention and education 71% Education: 17% had attended an educational program on ED's/DE. 21% have access to ED programs		

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Table 3. (continued)

Study (ref)	Sample	Sport coached	Coach experience/ education	Intervention	Coach knowledge and education	Coach attitudes/beliefs	Coach behaviours
Nowicka et al. (2013)	n = 18 Male 78% (n = 14) Female 22% (n = 4) National/ elite level	Aesthetic sports (n = 5) Weight class sports (n = 7) Endurance sports (n = 6)	Average age 42 years (range 24–60 years). 89% (n = 16) previously competed as athletes at national/ international level Average 17 years coaching experience (range 4–30 years)	Interview: Attitudes, beliefs and knowledge towards ED's.	Coaches reported the most common symptoms of AN and BN was a change in body weight. Coaches were more accurate at listing symptoms for AN than BN.	66% did not believe ED's to be a problem in their sport.	33% reported currently coaching an athlete with an ED. 61% reported they would speak to the athlete if they suspected DE or an ED. 11% would refer to an ED specialist. Direct quotes from coaches: Early intervention skills: 'I would sit down with the person concerned and simply ask: What the hell are you doing? Now you should tell me the truth. And tell her what can happen to the body.' Minimizing the problem: 'I can easily see if someone is eating the wrong way and I point out maybe you shouldn't eat these types of things. I just try to explain to them you actually become what you eat, and it is extremely important to eat the right food. I think you can kill some of these eating disorders if the athlete learns more about nutrition'.

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Table 3. (continued)

Study (ref)	Sample	Sport coached	Coach experience/ education	Intervention	Coach knowledge and education	Coach attitudes/beliefs	Coach behaviours
Plateau et al. (2015) UK	n = 11 Male 91% (n = 10) Female 9% (n = 1) National and International level	Track and Field	Average age 56.4 years (range 44– 69) Average 23.6 years coaching experience 45% (n = 5) coaching national level 55% (n = 6) coaching international level	Semi-structured interviews: Assessing coach beliefs and behaviours towards ED's.		36% believed there is an association between weight loss and DE. 45% believed menstrual dysfunction is an indicator of DE. Coaching styles adopted: 1. Supportive (strong, open relationships, value athlete health) 2. Avoidant (denial or unwillingness to address DE/ED concerns) 3. 3) Confrontational (use of scare tactics, strict rules and targets for weight and/ or training)	36% reported regularly weighing athletes. 55% identified changes in eating as a marker of DE. 55% felt confident in confronting athletes about concerns over DE.

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Table 3. (continued)

Study (ref)	Sample	Sport coached	Coach experience/ education	Intervention	Coach knowledge and education	Coach attitudes/beliefs	Coach behaviours
Martinsen et al. (2015) Norway	n = 76 Male 93% (n = 71) Female 7% (n = 5)	School sports (multisport)	Average age 36 years Average 5.9 years coaching experience 82% (n = 40) previously competed as athletes at national/international level 71% (n = 35) formal education in sports science/physical education	Randomised control trial: Education intervention (1 year): Questionnaire pre- and post-intervention: Knowledge of ED's, nutrition, weight regulation.	Intervention group: Total ED knowledge pre intervention was (mean) 57.1% post intervention 63.6% Total index value for ED knowledge pre intervention was 21.7 ± 6.8 and post intervention was 35 ± 7.2 (out of a possible 55) Pre intervention 38% of coaches pre intervention rated their knowledge to be 'somewhat good' Post Intervention 69% of coaches post intervention rated their own knowledge to be 'somewhat good' and 14% rates their knowledge as 'good'. 25% reported to have no good knowledge of DE 25% reported never receiving education on DE/ ED's.	19% believed amenorrhea is 'normal' and not serious. 22% believed amenorrhea is 'not normal' but usually not harmful. 77% believed the coach decides whether an athlete is fit/healthy to train.	91% never referred athletes at risk to a professional mental health practitioner. 37% never speak to their athletes about menstruation.
Di Cagno et al. (2018) Italy	n = 169 Female 100% Head coaches	Rhythmic Gymnastics	Average 15.2 years coaching experience (range 2–45 years)	Survey: assess knowledge, ability to identify athletes with DE.			

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Table 3. (continued)

Study (ref)	Sample	Sport coached	Coach experience/ education	Intervention	Coach knowledge and education	Coach attitudes/beliefs	Coach behaviours
Reagan (2018) USA	n = 79 Male 77.2% (n = 61) Female 22.8% (n = 18) High school coaches (head and assistant)	Tennis	Average age 43.97 years. 48% (n = 38) previously competed as a competitive athlete 82% (n = 65) possessed a college degree	Questionnaire: Knowledge of DE.	Questionnaire results: Total ED knowledge 68% 27% felt they lack knowledge on ED's. Subcategory knowledge results: Treatment and prevention 63.6% Signs and symptoms 60.0% Macronutrients and energy 57.0%	Responses to open ended questions based on scenarios: 26% (response frequency n = 18) understand the appropriate scope of practice. 14% (response frequency n = 10) of coaches recognise a registered dietician as an appropriate nutrition expert. 14% (response frequency n = 10) believe DE behaviours and are a potential issue.	Responses to open ended questions based on scenarios: 16% (response frequency n = 11) demonstrate an inappropriate scope of practice (relating to language and behaviour).

the context of RED-S,³³ with greater knowledge demonstrated in this context compared to earlier studies under the FAT model.^{17,21,27,28,32} Again, these coaches were drawn from an elite environment involved in a sport identified as ‘high risk’ for LEA (cross-country running).³³ Previous research has identified that a coach’s ‘experiential learning’ (e.g. personal learnings as an athlete, informal mentoring and/or practical coaching experience) complements knowledge obtained from ‘formal education’,^{44–47} which maybe an important consideration for future education initiatives.

Formal coach education programs (e.g. accreditation pathways) provide individuals with a sound knowledge base to practice within sporting environments.^{45,48} However, formal coach education is often developed on rationalistic lines and may not equip coaches with the intellectual and practical competencies (e.g. independent and creative thinking skills) to adapt in more complicated contextual situations.^{45,48,49} This becomes problematic when coaches encounter issues that fall outside of the ‘technocratic rationality’ of coaching.^{45,48} Accordingly, future education related to LEA should ensure coaches are engaged in the process of developing education experiences and provide a range of learning opportunities, combining formal and informal education. Structuring programs towards contextual challenges that coaches may encounter with regard to LEA and providing strategies to overcome these will bridge gaps between research and practice.^{45,47,48,50}

Coach attitudes/beliefs and behaviours of LEA extracted from studies specific to the FAT/RED-S and ED/DE

Findings from this review are indicative of inconsistencies in attitudes/beliefs and behaviours towards LEA, with a considerable proportion of coaches identified as employing language and/or behaviours of concern (related to menstrual function, physique and/or weight management).

Menstrual function

While some coaches are aware that menstrual dysfunction and/or amenorrhea is a concern for athlete health,^{17,21,26,29,32,36} many fail to exhibit strategies for prevention or identification of this nor have open dialogue with athletes regarding menstrual irregularity.^{17,21,26,29,32,36} Menstrual dysfunction and/or amenorrhea is a recognised symptom of LEA and if not rectified early, can lead to significant health implications (e.g. osteoporosis, stress fractures, injury and/or infertility).^{1,7,51} Coaches may avoid communication on this topic due to a lack of confidence or in fear of saying something that could be interpreted as ‘inappropriate’.^{21,36} This could lead to missed opportunities in identifying athletes at risk.^{1,18,52,53}

Coaches identified to be more aware of the risks associated with menstrual dysfunction/amenorrhea demonstrated greater confidence and/or comfort engaging in conversations with athletes.^{17,21,26,32,42} These attributes were more frequently observed among female coaches.^{17,32} Recognising that a two-way relationship exists between the coach and athlete, it is also important to be cognisant of how confident and/or comfortable an athlete feels engaging in conversations about menstrual function.^{54,55} Indeed, athletes have reported a reluctance to confide in coaches due to feelings of embarrassment and/or fearing appearing weak.⁵⁴ However, two recent studies indicate that female athletes may feel more comfortable and confident speaking to female coaches on this topic.^{55,56} Findings from the included studies in this review did not allow for a detailed exploration of the difference between male and female coaches’ perspectives on discussing reproductive function. Nonetheless, aforementioned studies suggest that gender differences warrant consideration when developing an optimal study and education program for coaches.^{17,32} A greater number of trained female coaches will likely improve communication on menstrual health, supporting athlete health.^{54,57} In male-dominated coaching environments, an immediate strategy could involve prioritising opportunities to increase female representation within the training environment (e.g. via a physiotherapist, doctor or welfare officer).

Physique and weight management

This review highlights some concerning behaviours related to physique and weight management practices employed by coaches (e.g. regular body fat/weight assessments, emphasis on physique, dialogue relating to weight and/or appearance).^{17,26,28,29,37,40} Clearly the use of physique profiling and management of weight is closely aligned with performance in some sports,^{58,59} particularly in the case of weight-categorized sports.^{59,60} Thus, these practices could be a critical element of performance management of these athletes.^{59,60} For other sports, associations with weight/physique and performance may be tenuous yet appears overemphasised and/or mismanaged in the coaching environment.^{17,22,26,28,37} Sporting cultures where athlete weight and/or physique is a focus may predispose individuals to potential harm.^{13,58} Accordingly, it is important that coaches in any individual sport recognise the extent to which physique and/or weight management is related to performance in the athletes they manage.

From an applied perspective, there has been increased recognition of the risks associated with coach comments and/or use of inappropriate behaviours towards weight and/or physique (e.g. regular body monitoring/weigh-ins, body shaming).^{22,23,37,61–65} Currently, limited guidance exists for how physique management and/or weight related discussions should be conducted within the

context of specific sports. Hence, it is apparent that coaches require greater support and structures around them, which orient their behaviours towards optimal performance without compromising athlete health.

Coach athlete relationship

Evidence from the current review suggests that coach knowledge, attitudes/beliefs and behaviours may be influenced by the coach–athlete relationship.^{39,40} It was not the intention of this review to explore coach–athlete relationships in detail. Nonetheless, a number of different relationships (e.g. avoidant, supportive, confrontational)^{39,40} were identified to influence the development of knowledge, attitudes/beliefs and behaviours regarding LEA. Practically, the interaction between a coach and athlete on issues associated with LEA is an important consideration that requires further development to contextualise how best to guide coaches in this area.

Directions for enhancing coach knowledge, attitudes, beliefs and/or behaviours towards LEA and/or ED/DE

There is increased recognition of the need for cultural change and systematic structural modifications in sport to better protect athlete health.^{6,18,22,23} This work has commenced in some sports (e.g. Gymnastics Australia Body Positive Guidelines,²⁴ Australian Institute of Sport Disordered Eating in High Performance Sport¹¹). However, beyond these attempts there appears to be limited information on educational resources and/or programs available for coaches.³³ While coaches should not be expected to directly ‘treat/resolve’ cases of LEA/RED-S, they should (1) create environments that mitigate risks; (2) be aware of signs and symptoms; and (3) work with support staff (e.g. sports medicine physician, sports dietician) to appropriately manage athletes with or at risk of LEA.^{6,11,13,18} This review suggests that strategies to enhance coach, knowledge/attitudes, beliefs and behaviours towards LEA are likely to require a sport specific focus. That is, considering the context in which coaches work, exploring formal and informal learning opportunities, offering seminars and workshops, creating awareness campaigns, understanding coach–athlete relationships, and addressing gender imbalances in the coaching environment.

Limitations

One of the limitations identified in this review was that, to date only one study has explored knowledge of LEA in the context of the more recent RED-S concept.³³ The paucity of recent data prevents any determination of whether knowledge, attitudes/beliefs and/or behaviours have changed

since the introduction of this new framework. The studies included in this review employed a wide range of tools to assess coach knowledge, attitudes/beliefs and behaviours towards LEA and ED/DE, with the heterogeneity of the literature restricting direct study comparisons. Furthermore, the study methodologies and outcomes precluded us from exploring how coach knowledge, attitudes/beliefs and/or behaviours may vary between sports, level of experience, gender, those working with amateur versus elite or those working in sports with/without an emphasis on physique. Developing a population specific validated tool may enable a greater understanding and appraisal of coach knowledge, attitudes/beliefs and behaviours. Furthermore, many studies were undertaken in the USA, limiting our international perspective. It is possible other research in this field may exist (e.g. non-English articles), however this review employed an inclusion/exclusion criterion restricting articles to only those published in English (as per our methods). Desirability bias was also recognised as a potential limitation. For example, some coaches indicated peers employed inappropriate behaviours, yet denied incorporating these practices in their own coaching.³⁷

Future directions for research

This review considers the existing research exploring coach knowledge, attitudes/beliefs and/or behaviours towards LEA. Recognising the results have been drawn from a limited number of heterogeneous studies, there are key considerations required for future research. Given the limited data available, this review was unable to provide a comprehensive understanding of some factors. This includes the possible differences between male and female coaches, the sporting context, coach experience and/or whether a coach’s age influences their perception of the seriousness of LEA. Furthermore, with many of the included studies conducted in the USA, it is unclear if coach knowledge, attitudes/beliefs and/or behaviours vary on a broader international level. As such, an opportunity exists for future studies to represent the coaching environment across these varying spectrums. This is likely to be important when considering the development of future education initiatives, which may require different approaches depending on the gender, sport, experience, age and/or the sporting context (e.g. recreational or elite).

It is also important to acknowledge changes in rhetoric used since the earliest study (1998) to the most recent (2021) in this review regarding LEA and evolving models associated with this concept (e.g. FAT, RED-S). This has also occurred alongside a heightened awareness and promotion of concerns for athlete health when EA is mismanaged and/or inadequately supported in the coaching environment.^{1,8} Coaches are presented with a complex challenge to ensure they adapt their language and coaching practices in line with evolving research to support the next generation

of athletes. In addition, coaches of today may find themselves working with athletes across varying age groups and levels. This is important in terms of recognising where there may be a need to adapt their coaching style; especially with developing athletes to ensure they are not predisposed to training loads and performance pressures, which may be inappropriate during a time of significant physical, psychological and social developments.⁶⁶ Sporting organisations should be encouraged to capitalize on opportunities to examine their coaching environment and the coaching norms, values, behaviours and/or practices. This may be a pivotal element for the development of sport specific strategies; supporting coaches to create environments that mitigate potential harms to athlete health.

Conclusion

Coaches are important figures of influence with potential to create environments that influence athlete health and performance outcomes. The majority of findings from this review were drawn from studies conducted prior to LEA being defined as a concern for athlete health, which limits our understanding of the contemporary knowledge, attitudes/beliefs and behaviours of coaches on this important issue. An opportunity exists for key stakeholders to develop comprehensive coach education frameworks, which equip coaches with the adequate capability, opportunity and motivation to support athletes and avoid the consequences of LEA.


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Supplemental material

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