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Sports Dietitian practices for assessing and managing athletes at risk of low energy availability (LEA)

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ABSTRACT

Objectives: To characterise the assessment and management practices employed by Sports Dietitians when assessing and managing athletes at risk of low energy availability (LEA).
Design: 55 Sports Dietitians participated in an online questionnaire that captured the typical methods used to identify and manage LEA in athletic populations.
Methods: The questionnaire consisted of 27 questions which explored common methods used to identify and manage LEA, as well as dietary methods employed and barriers experienced by Sports Dietitians.
Results: Broadly, the top 3 nutrition-related priorities for respondents were nutrition strategies to support training, competition, and recovery while '*LEA*' was ranked fifth. '*Dietary intake*', '*menstrual function*' and '*training load* (*km/week*)' were the primary methods used to assess LEA and respondents were 'confident' in their ability to correctly identify athletes at risk. Among support personnel, coaches were rarely a referral source for management of LEA but did present frequent communication difficulties. Respondents indicated athletes have concerns about undesirable changes in body composition when providing recommendations of increased energy intake for LEA management.
Conclusions: Sport Dietitians appear to recognise and prioritise LEA management in athletes, but assessments are limited to dietary intake and training load (km/week); with collaborative approaches to LEA management lacking. Sports Dietitian may be overconfident in their ability to identify LEA as only a limited number of assessment methods are commonly used. Access to reliable assessments methods and collaborative management approaches are needed to improve athlete care when suspected of LEA.

Practical Implications

- The athlete support team, including the sports nutrition professional, should incorporate a range of tools such as training load and dietary intake assessments, DXA, RMR and pathology to investigate and monitor the EA status of athletes, while recognising their advantages and disadvantages.
- Sports nutrition professionals should work collaboratively with athletes and coaches when managing athletes at risk of developing LEA, understanding that further education regarding the health and performance implications of LEA is likely needed.
- Convenient, carbohydrate and protein rich foods and fluids such as 'smoothies' scheduled around training sessions are appropriate strategies that should continue to be used by Sports Dietitians to increase energy intake when managing athletes at risk of LEA.
- When implementing strategies to increase energy intake with athletes at risk of LEA, sports nutrition professionals should recognise that body composition concerns may prevent some athletes from implementing appropriate strategies.
- When providing sports nutrition advice to athletes, health professionals should be cognisant of managing risks associated with athletes developing LEA, while managing nutrition-related performance considerations such as hydration, body composition management and supplements.

1. Introduction

Daily food and fluid intakes that provide sufficient dietary energy to match the energetic cost of exercise are imperative for optimal function of fundamental physiological processes such as cell metabolism, whole-body thermogenesis, reproduction, immune responses, and movement.[1,2] An athlete's daily energy needs, hydration requirements and physique differ substantially from a sedentary individual due to the additional energetic cost of training.[3,4] This can present challenges for an athlete and their support team as high daily energy intakes are required to ensure adequate energy availability (EA; 45 kcal/kg FFM/day).[2] EA is described as the quantity of dietary energy that remains to support physiological

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functioning after deducting the energetic cost of exercise.[1] Inadequate EA resulting from increases in exercise energy expenditure (EEE), decreases in energy intake (EI), or a combination of both, perturbs the endocrine milieu.[5] This results in undesirable physiological responses including disruptions to several metabolic hormones such as Thyroid Hormone (T_3), Luteinising Hormone (LH), Follicle Stimulating Hormone (FSH), Insulin Like Growth Factor 1 (IGF-1), Leptin and Ghrelin.[6,7] LEA has been recognised as the underlying contributor behind the development of the Female Athlete Triad and Relative Energy Deficiency in Sport (RED-S).[8]

LEA among athletes can be attributed to behavioural, psychological, training and/or dietary-related factors.[9] Athletes may also experience LEA due to the influence of athlete support personnel, either unintentionally due to poor nutritional knowledge or through conscious encouragement of lean physiques for optimal performance.[10] Moreover, successful identification and monitoring of athletes at risk of LEA is likely optimal when the athlete support personnel work collaboratively, are well informed and have access to efficacious LEA assessment tools and management pathways.[11]

To date, studies have investigated the knowledge of LEA among coaches[12,13] and athletes.[14] Notably, only a small number of respondents appear adept in correctly identifying the LEA component of the Female Athlete Triad, with female coaches more likely to recognise contributing factors to the Triad and/or RED-S.[13] More broadly, while international sports federations aim to support the health of elite athletes, education specific to RED-S appears lacking.[15] While evidence related to identification of athletes with LEA is continually expanding, studies on the knowledge of LEA among various athlete support personnel and associated issues such as RED-S are lacking. Given the role of Sports Dietitians in the early identification and management of LEA, understanding current practice pathways is crucial to improving athlete care.

This study characterised assessment and management practices of Sports Dietitians when determining EA status in athletes. The primary aims were to define the assessment tools used by Sports Dietitians to identify and manage athletes with LEA, and to determine current referral pathways for athletes at risk. The present study also elucidated barriers Sports Dietitians face and subsequent dietary strategies employed when managing LEA.

2. Methods

A total of 55 Accredited Sports Dietitians, recruited through Sports Dietitians Australia (SDA; $n = 228$ members) completed an online questionnaire using Qualtrics Experience Management (Qualtrics XM) Survey Software (Qualtrics, Drive Provo, UT, USA) to characterise EA assessment and management practices. The questionnaire was available for 3 months (November 2020–February 2021), with email reminders distributed via SDA communication platforms. Permissions to complete the study were granted by the relevant ethics committee in Australia (BUHREC; no. AB03576). Prior to commencement, respondents provided informed consent and were advised responses would remain anonymous.

The questionnaire was informed by a similar study on international sports federations' prioritisation of health and safety issues in sport.[15] Questions were developed using the Australian Institute of Sport RED-S Athlete Management Pathway Infographic (see Supplementary File 1). This infographic was developed by experienced Australian Sports Dietitians to emphasize key areas for clinical management of RED-S including athlete presentation, athlete referral, LEA assessment and monitoring tools, and disordered eating (DE) assessment. Prior to distribution, the questionnaire was reviewed by expert Sports Dietitians with greater than 20 years' experience ($n = 4$). The questionnaire included 33 items distributed across four main areas (demographic characteristics, identification and monitoring, dietary management, and barriers to management of LEA). The topics were addressed via two different 5-point Likert scales (never, rarely, sometimes, often, and always; not important at all, low importance, neither nor, important, and very important) and 10-point scale style questions (1 indicated 0% confidence, 10 indicated 100% confidence; see Supplementary File 2).

Questionnaire data was analysed using the Statistical Package for Social Sciences (SPSS; version 26.0, IBM Corporation, Chicago, IL, USA). Where appropriate, descriptive statistics were employed to report questionnaire data. Categorical data are presented as a percentage of total responses n (%) and any continuous data are presented as mean ± SD. Chi-squared tests (categorical variables) and one-way ANOVAs or independent *t*-tests (continuous variables) were employed to compare differences in LEA assessment and management against various participant characteristics such as gender, primary employment, SDA membership status and athlete clientele. Significance was set at $p \leq 0.05$.

3. Results

A total of 55 Sports Dietitians (females $n = 50$, 90.9%; SDA member breakdown $n = 228$, 82% female; $n = 49$, 18% male) completed the questionnaire (see Supplementary File 3). Respondents most frequently worked greater than 10 h per week in sports nutrition (76.4%, $n = 42$) and conducted 75.0% of athlete consultations in-person. Respondents provided services to comparable numbers of male and female athletes (males 48.8% ± 20.3%; females 51.2% ± 20.3%, respectively), and most respondents commonly consulted with elite or sub-elite athletes ($n = 42$, 76.4%).

Most respondents reported a national sporting organisation (NSO), state sporting academy or private practice as their primary employer (69.1%, $n = 38$). A high proportion of respondents were consultants to team sports including rugby and basketball (69.1%, n = 38). Other sports included cycling (35.2%, $n = 19$), ultra-endurance sports

Table 1
Nutrition-related priorities among Sports Dietitians ($n = 55$ respondents).

Nutrition-related priority	Very important (%)	Important (%)	Neither nor (%)	Low importance (%)	Not important at all (%)
Daily nutrition strategies that support training performance	83.7	16.3	0	0	0
Nutrition strategies to optimise competition performance	71.4	26.5	2.0	0	0
Nutrition strategies to optimise recovery following competition	61.2	36.7	2.0	0	0
Eating disorders/disordered eating	59.2	26.5	6.1	8.2	0
Low energy availability (LEA)	57.1	38.8	2.0	2.0	0
Daily nutrition strategies that enhance training adaptations	55.1	38.8	4.1	2.0	0
Illness prevention with nutrition-based strategies	44.9	46.9	6.1	2.0	0
Hydration strategies for training	46.9	44.9	6.1	2.0	0
Injury prevention with nutrition-based strategies	46.9	44.9	6.1	2.0	0
Managing bone health	42.9	51.0	4.1	2.0	0
Managing iron status	42.9	46.9	10.2	0	0
Nutrition lifestyle skill development	36.7	46.9	10.2	6.1	0
Supplement use	32.7	49.0	12.2	6.1	0
Body composition management - increasing muscle mass	20.4	63.3	12.2	4.1	0
Body composition management - decreasing fat mass	14.3	63.3	14.3	6.1	2.0
Mindful eating	14.3	40.8	30.6	14.3	0
Body composition management - decreasing muscle mass	8.2	24.5	26.5	26.5	14.3

(30.2%, $n = 16$), triathlon (29.6%, n = 16), rowing (29.6%, n = 16), aesthetic sports such as gymnastics and/or dancing (25.5%, $n = 14$) and combat sports (19.6%, $n = 10$).

The top three nutrition priorities for Sports Dietitians (expressed as the number of '*very important*' responses) when consulting with athletes were (1) '*daily nutrition strategies that support training performance*' ($n = 46$, 83.7%), (2) '*nutrition strategies to optimise competition performance*' ($n = 39$, 71.4%) and (3) '*nutrition strategies to optimise recovery following competition*' ($n = 34$, 61.2%). '*Eating disorders/DE*' was ranked fourth (n = 33, 59.2%), while '*LEA*' was the fifth-ranked nutrition-related priority ($n = 31$, 55.1%) (Table 1).

Less than half of respondents considered '*illness and injury prevention with nutrition-based strategies*' ($n = 26$, 46.9%), '*managing iron status*' and '*managing bone health*' ($n = 24$, 42.9%) as '*very important*' priorities. Approximately one third of respondents recognised '*supplement use*' as a '*very important*' priority ($n = 18$, 32.7%). The lowest ranked nutrition-related priorities among respondents were body composition management '*increasing muscle mass*' ($n = 11$, 20.4%), '*decreasing fat mass*' ($n = 8$, 14.3%) and '*decreasing muscle mass*' ($n = 5$, 8.2%).

Respondents reported that athletes at risk of LEA most frequently ('*always/often*') presented with '*recurrent injury/illness*' ($n = 31$, 63.3%) and an '*inability to meet daily energy requirements due to reduced dietary intake*' (n = 31, 63.2%). It was uncommon for Sports Dietitians to consult with male athletes presenting with '*reduced sex drive*' relating to LEA ($n = 5$, 10.2%) and Sports Dietitians '*rarely/sometimes*' consulted with athletes who had '*low bone mineral density*' (BMD; $n = 41$, 83.6%).

Most respondents reported '*always/often*' assessing '*dietary intake*' ($n = 44$, 89.8%) and '*menstrual function*' ($n = 43$, 87.8%) to identify and monitor athletes at risk of LEA (n = 44, 89.8%). Respondents also assessed '*training load*' for athlete monitoring ($n = 37$, 75.5%), with '*external load (km/week)*' the predominant tool used ($n = 29$, 63.0%). The tool '*never*' or '*rarely*' used to assess training load was an '*accelerometer*' ($n = 36$, 78.3%) (Table 2).

Less than half of the respondents reported '*always/often*' using the '*Low Energy Availability in Females Questionnaire (LEAF-Q)*', '*other pathology (e.g., IGF-1, insulin, iron)*' or '*sex hormone pathology (LH, FSH, Testosterone)*' as a means of assessing an athlete's EA status ($n = 22$, 44.9%; $n = 21$, 42.9%; $n = 23$, 46.9% respectively). Respondents reported '*never/rarely*' or '*sometimes*' using '*RMR*' to assess EA status ($n = 32$, 65.2%).

The most prevalent signs or symptoms employed by respondents to assist in identifying/monitoring an athlete at risk of LEA were '*residual (ongoing) fatigue*' ($n = 46$, 95.9%), '*training performance*' ($n = 44$, 91.7%) and '*recovery between sessions*' (n = 44, 91.7%). Respondents rated the confidence in their ability to correctly assess an athlete's risk of LEA as 7.4 ± 1.3 on a 10-point scale. Self-reported measures of confidence were skewed (−0.440, SE 0.340) towards being more confident. There was no significant difference in an individual's confidence to identify LEA across different levels of professional expertise among Sports Dietitians.

Most respondents reported assessing DE risk when consulting with athletes ($n = 35$, 71.4%). '*Preoccupation with food, calories, body shape and/or weight*' ($n = 33$, 100%), or '*presence of restrictive eating*' (n = 33, 100%) were consistently used by all respondents to identify those at risk. '*Low body fat*' ($n = 20$, 60.6%) and '*low body weight/BMI*' ($n = 22$, 66.7%) were less commonly used signs and symptoms to identify DE (see Supplementary File 4).

The prevailing goal identified by respondents to improve an athlete's EA based on dietary assessments and training log data (km/week) was to '*increase in EI to align with EEE with a focus on carbohydrate and protein rich foods*' ($n = 40$, 87.0%) '*Pre, during and post-training snacks*' were the predominant dietary strategy used by respondents to increase EI ($n = 44$, 95.7%), while '*Increasing the size of main meals*' was the least common method adopted ($n = 22$, 47.8%). The most frequently reported convenience food/fluid to increase EI was '*smoothies*' ($n = 39$, 84.8%).

Most commonly, respondents reported that athletes would present without referral ($n = 24$, 49.0%) or be referred by a sports physician for LEA management ($n = 21$, 42.8%; Fig. 1A). When managing LEA, respondents commonly engaged directly with the athlete ($n = 38$, 77.6%), sports physician ($n = 37$, 75.5%), coach ($n = 30$, 61.2%) and psychologist ($n = 25$, 49.0%; Fig. 1B). Respondents reported facing the greatest difficulties with coaches when managing LEA ($n = 22$, 45.7%; Fig. 1C).

Respondents indicated '*increases in body weight and/or undesirable impacts on body composition*' the most common concern raised by athletes when dietary recommendations for LEA management involved increases in energy intake ($n = 38$, 82.6%). There was no significant difference ($p = 0.848$) in perceived concerns across different levels of athletes (elite vs non-elite).

4. Discussion

This is the first study to examine the current practices of Sports Dietitians when assessing and managing athletes at risk of LEA. This study provides novel insights highlighting that Sports Dietitians perceive a lack of engagement and communication with particular support personnel in identifying and managing LEA and experience reluctance from coaches and athletes to implement dietary changes to increase EI in LEA management. The study also revealed that Sports Dietitians primarily relied on menstrual dysfunction, dietary assessments, and training logs when assessing LEA. These findings are of particular importance for Sports Dietitians, who play a central role alongside other support personnel in managing athletes at risk of LEA.

A key finding from this study is that athletes either present without formal referral or are referred by a sports physician to a Sports Dietitian for LEA management. Referrals were rarely received from other support personnel. Coaches typically have the greatest opportunities for interaction with athletes, often occurring daily and for a minimum of several hours each week. Interestingly, previous studies indicate that coaches have a low proficiency for correctly identifying the presence of LEA among female athletes.[13,14,16] Moreover, while loss of menstruation among female athletes is widely regarded as a primary indicator for identifying LEA, recently Logue and colleagues reported that endurance coaches view this physiological response as "normal" in their athletes.[17] While it's unclear why athlete support personnel and family/spouses have low rates of referral to Sports Dietitians for athletes at risk of

Table 2
Tools currently used by Sports Dietitians to identify and monitor athletes at risk of LEA (n = 49 respondents).

Method	Always (%)	Often (%)	Sometimes (%)	Rarely (%)	Never (%)
Dietary intake assessment (i.e., 24 h recall, food diary)	57.1	32.7	10.2	0	0
Menstrual function	53.1	34.7	6.1	2.0	4.1
Training load assessment	34.7	40.8	18.4	4.1	2.0
Resting metabolic rate (RMR)	14.3	20.4	30.6	22.4	12.2
Low Energy Availability in Females Questionnaire (LEAF-Q)	10.2	34.7	30.6	12.2	12.2
Body weight assessment & management	8.2	42.9	38.8	8.2	2.0
Other pathology (i.e., IGF-1, insulin, iron)	4.1	38.7	32.7	16.3	8.2
Sex hormone pathology (i.e., LH, FSH, TES)	2.0	44.9	30.6	16.3	6.1

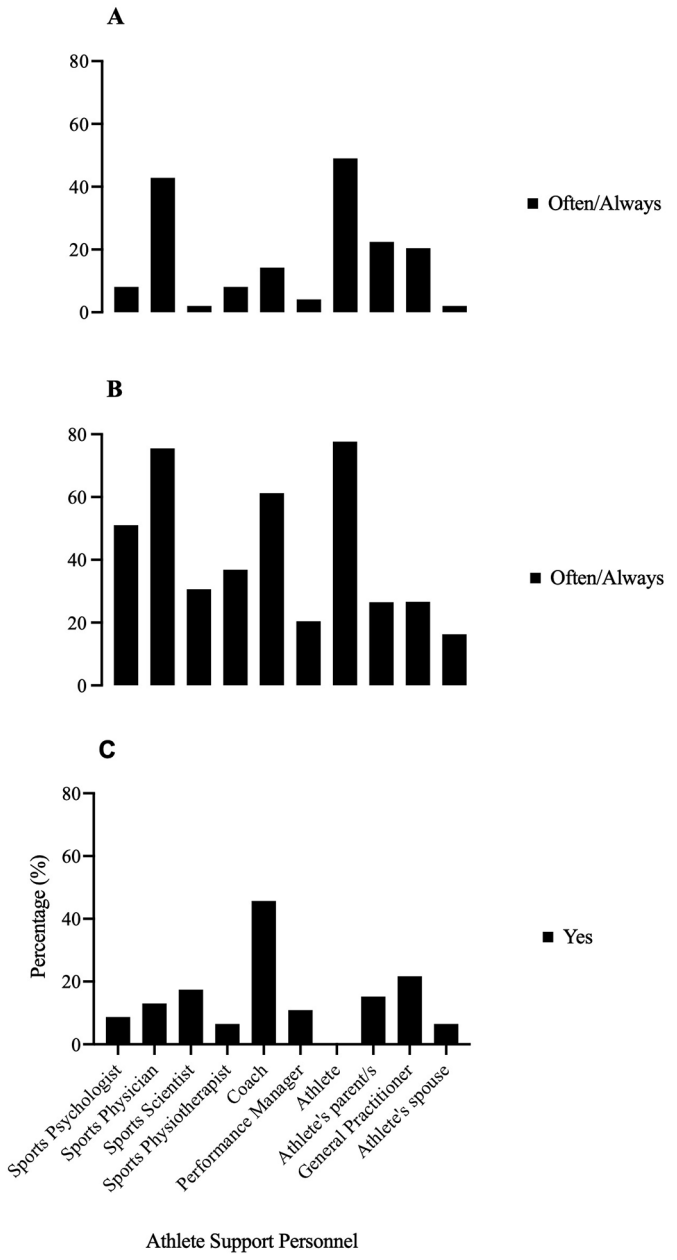

Fig. 1. Sport Dietitians interactions with various athlete support personnel for the management of low energy availability (LEA) among athletes including (A) rate of referral (often/always), (B) rate of engagement (often/always) and (C) likelihood of experiencing any difficulties when managing low energy availability ($n = 49$ respondents).

LEA, the most likely explanation is a lack of awareness of the inherent health and performance impacts of LEA.[17] A further complication is that athletes appear ill acquainted with the characteristic signs and symptoms of LEA.[18,19] Given athlete health and well-being is of equal importance to optimising athletic performance, additional efforts to promote awareness regarding the diagnosis and subsequent management of LEA is paramount across all members of the athlete support network. Nonetheless, at present athletes and support personnel alike, appear unacquainted with indicators or physical manifestations of LEA and subsequent health and performance implications. Determining the underlying reason(s) for this lack of awareness is an important area for future research.

Sports Dietitians frequently engaged with coaches, but commonly reported experiencing difficulties with coaches when managing LEA. Previously, coaches have been reported to commonly rely on body composition changes (i.e., skinfold assessments) to determine the adequacy of an athlete's diet rather than comprehensive assessments of EI/EEE and other additional factors routinely collected by Sports Dietitians.[17] As LEA is a relatively new concept, the idea of modifying dietary intake to improve body composition may seem counterintuitive to some coaches. The possibility that nutritional interventions to correct LEA will result in long-term changes in body composition that prove beneficial to performance, is likely difficult for coaches to comprehend.[17] Education may improve the understanding of the underlying physiological processes at play in LEA and provide greater acceptance of appropriate dietary strategies.

Notably, athletes also appear concerned about increases in body weight and/or undesirable impacts on body composition as this was reported as the most prevalent barrier experienced by Sports Dietitians attempting to increase EI to improve EA. Whether there is a direct relationship between coach and athlete attitudes is unclear, but both appear hesitant to increase EI to improve EA due to expectations of unfavourable changes to body composition.[17]

While body composition remains a key focus for athletes and their support personnel (namely, coaches), it was not a main nutrition-related priority for Sports Dietitians included within this study. Historically, Sports Dietitians have been engaged by athletes/sports to facilitate changes in body composition with a focus on reducing body fat levels and/or increasing lean body mass (LBM). More recently however, as awareness surrounding LEA and athlete health and well-being has increased, the scope and focus of Sports Dietitians has broadened. Sports Dietitians that participated in this study, prioritised strategies that promote health and wellbeing, rather than strategies that facilitate body composition changes that may contribute to the development of LEA. To avoid being excluded from athlete support personnel, Sports Dietitians should carefully manage body composition requirements of athletes to optimise performance, while being vigilant to monitor EA status with appropriate tools that can be incorporated into athlete servicing.

Sports Dietitians in this study focussed on increasing carbohydrate and protein rich foods using pre, during and post-training snacks to improve EI of athletes at risk of LEA, despite the apparent hesitancy of athletes and coaches. This is a logical, evidence-based dietary strategy given manipulating EI around key training sessions promotes maintenance of LBM and training outcomes, which in turn can enhance exercise-induced adaptation and optimal performance.[20–22] To reduce fear of undesirable body composition changes when EI is increased, considered and consistent reinforcement of the importance of fuelling appropriately to support daily training should be a priority across all members of the athlete support team. Moreover, when implementing a carefully periodised and gradual increase in EI athlete weight gain can be minimized by planning appropriately for training fluctuations across the season.[17] The findings from the present study reinforce the need for LEA education to athletes, coaches, and other support personnel to avoid undesirable health and performance outcomes associated with LEA.[8,11]

When assessing an athlete's EA status, Sports Dietitians were less likely to use RMR, DXA, LEAF-Q and sex hormone or other pathology. More broadly, athletes within Australia, have limited access to RMR, DXA and pathology assessments for routine sports-related servicing (Author GRC personal observations). Further the impracticalities of conducting reliable assessments on free-living athletes (i.e., present fasted and rested, early morning with access to qualified technicians and equipment) present additional challenges for routine monitoring with these tools. Instead, respondents appeared to employ menstrual function as a primary assessment method and relied on self-reported athlete dietary intake and training load assessment. While menstrual function is commonly used to assess an athlete's LEA status, it has poor temporal resolution because it manifests over an extended period of time and substantially delays identifying an athlete's inability to meet daily energy expenditure.[23] Interestingly, while Sports Dietitians provided

services to comparable numbers of male and female athletes, sex drive was not a tool commonly used to assess LEA status. Perhaps female Sports Dietitians, who were the main respondents to this questionnaire ($n = 50$, 90.9%) were reluctant to ask this question when consulting male athletes.

Previous field-based studies have also reported inherent issues in the self-reporting of dietary intake. Specifically, poor reliability in quantifying typical food and fluid intake and low precision in reported compared with actual food intake are routinely observed with self-reported dietary intakes.[24–26] Finally, despite a multiplicity of training load data readily available in many sports, the information is not easily and accurately translated to individual EEE.[27] Accordingly, clear variations and limitations exist in the estimation of an athlete's nutrient intake and energy expenditure, even when undertaken by experienced Sports Dietitians over a 7-day period.[28] While Sports Dietitians in the present study appeared confident in their ability to correctly identify athletes in LEA they typically rely on questionable tools to make clinical decisions about an athlete's EA status.[28] The current methods used by Sports Dietitians included in this study may be cost-effective and non-invasive, but other methods such as DXA, RMR and pathology may provide a more accurate assessment in identifying and monitoring athletes at risk of LEA.[10,26] Improved education and training of Sports Dietitians to expand the use of available LEA assessment tools alongside working more collaboratively with members of the athlete's support team would assist in optimising athlete care.

DE behaviours and/or diagnosed eating disorders are potential drivers of the manifestation of LEA among athletes.[29] Interestingly, while most Sports Dietitians in this study perceived DE and eating disorders as being a very important nutrition-related issue, approximately one-in-six placed low importance or perceived the topic as not important at all. The responses also indicate that changes in body fat/weight were not a focal point for DE assessment among respondents. This is notable because changes in body weight have been identified as an indicator of DE that should be considered when managing at-risk athletes.[30] This may have implications for the identification and management of LEA as a small proportion of Sports Dietitians fail to monitor DE which can be a significant underlying contributor to the development of LEA.

5. Conclusion

To our knowledge, this is the first study to examine the current practices of Sports Dietitians when assessing and managing athletes at risk of LEA. While Sports Dietitians prioritise LEA management, they experience difficulties when engaging with athlete support personnel (i.e., coaches) and commonly utilise a limited range of LEA assessment tools (i.e., dietary intake and training load assessment) shown to have poor temporal resolution. As such, it is unclear if Sports Dietitians' confidence in their ability to identify LEA is justifiable. Routine use of methods that provide more reliable assessment of LEA (i.e., DXA, RMR, pathology) and collaborative management approaches among athlete support personnel are warranted to assist practitioners and improve athlete care.

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Data sharing statement

There is no unpublished data from the study.

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Declaration of Interest Statement

None declared.

Confirmation of Ethical Compliance

Permissions to complete the study were granted by the relevant ethics committee in Australia (Bond University Human Research Ethics Committee; BUHREC, no. AB03576).

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