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Investigating the prevalence of low energy availability, disordered eating and eating disorders in competitive and recreational female endurance runners

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ABSTRACT

Eating disorders (ED), disordered eating (DE) and low energy availability (LEA) can be detrimental to health and performance. Previous studies have independently investigated the prevalence of ED, DE or LEA; however, limited studies have combined methods identifying risk within female runners. The aim of this study was to identify the prevalence of ED, DE and LEA in United Kingdom-based female runners and associations between age, competition level and running distance. The Female Athlete Screening Tool (FAST) and Low Energy Availability in Females Questionnaire (LEAF-Q) were used in a cross-sectional study design. A total of $n = 524$ responses eligible for analysis were received. A total of $n = 248$ (47.3%), $n = 209$ (40%) and $n = 49$ (9.4%) athletes were at risk of LEA, DE and ED, respectively. LEAF-Q scores differed based upon age (Age: $H_{(3)} = 23.998$, $p \leq .05$) and competitive level (Comp: $H_{(1)} = 7.682$, $p \leq .05$) whereas FAST scores differed based on age (Age: $F_{(3,523)} = 4.753$, $p \leq .05$). Tukey's post-hoc tests showed significantly higher FAST scores in 18–24 years compared to all other age categories ($p \leq .05$). Stepwise multiple regression demonstrated age and competitive level modestly predicted LEAF-Q scores ($R^2_{adj} = 0.047$, $F_{(2,523)} = 13.993$, $p \leq .05$, VIF = 1.0) whereas age modestly predicted FAST scores ($R^2_{adj} = 0.022$, $F_{(1,523)} = 12.711$, $p \leq .05$, VIF = 1.0). These findings suggest early identification, suitable screening methods and educational intervention programmes should be aimed at all levels of female endurance runners.

KEYWORDS
Physical activity; menstruation; nutrition; health

Highlights

- A total of 524 female endurance completed a self-administered, online questionnaire screening for low energy availability, disordered eating and eating disorders risk.
- Age and competitive level modestly predicted low energy availability and age modestly predicted disordered eating and eating disorders in female endurance runners.
- A higher percentage of 18- to 24-year-old female endurance runners were at greater risk of low energy availability, disordered eating and eating disorders compared to other age categories.
- These findings highlight the need for regular screening in order to aid early interventions to prevent potential decrements in performance and health as endurance runners mature.

1. Introduction

Energy availability is energy intake minus exercise energy expenditure expressed relative to fat-free body mass, subsequently, low energy availability (LEA) occurs when there is insufficient energy to support normal physiological functions (Logue et al., 2020; Loucks, Kiens, & Wright, 2011). To conserve energy, a range of physiological and endocrine adaptations occurs that can negatively affect health and performance, in particular bone health and reproductive function (Slater, McLay-Cooke, Brown, & Black, 2016). Long-term LEA can have serious health consequences that include impaired menstrual, gastrointestinal and cardiovascular function, reduced metabolic rate, reduced bone mineral density (BMD), an increased risk of illness and injury, reduced performance, fatigue and poor mental health (Logue et al., 2020; Mountjoy et al., 2014). These symptoms are collectively known as the syndrome relative energy deficiency in sport (RED-S) (Mountjoy et al., 2014).

LEA is widely recognised as the driving factor in RED-S (Logue et al., 2020). Researchers have demonstrated that when energy availability (EA) is reduced to below 30 kcal kg·FFM d^{-1}, (a threshold near resting metabolic rate), for five days or more, the hypothalamic-pituitary-gonadal axis is disrupted and bone formation is impaired (Ihle & Loucks, 2004; Loucks & Thuma, 2003). LEA may arise for several reasons, including an inadequate understanding of the energy requirements of sport and exercise, particularly during periods of increased training

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load (Black, Baker, & Sims, 2020; Melin et al., 2015) or the reliance on appetite, which is not a reliable indicator of energy requirements and may be suppressed following intense exercise (Logue et al., 2020; Loucks, 2004; Slater et al., 2016). Additional reasons for LEA may include an intentional restriction in calorie intake, to reduce body weight for performance and/or aesthetic reasons (Black et al., 2020; Nattiv et al., 2007); or the result of a subclinical, or clinical, eating disorders (ED). EDs are serious mental health illnesses associated with significant psychological distress and have the highest mortality rate of any mental health condition (Murray, Pila, Griffiths, & Le Grange, 2017). It is recognised that disordered eating (DE) behaviours and EDs are a major cause of LEA, therefore screening for DE/ED in addition to LEA is recommended (Logue et al., 2020). Despite this, there remains a lack of screening in practice (Knapp, Aerni, & Anderson, 2014), and a lack of research into the relationship amongst DE behaviours, ED and LEA.

Measurement of LEA is challenging: it requires accurate measures of EA, for which there is currently no gold standard measurement (Logue et al., 2019; Melin et al., 2014a). However, Melin, Torstveit, Burke, Marks, and Sundgot-Borgen (2014b), developed the Low Energy Availability in Females questionnaire (LEAF-Q) to address this issue. This 25-item, validated screening tool, evaluates the main symptoms associated with LEA, including menstrual and gastrointestinal function, injury and use of the contraceptive pill (Melin et al., 2014a). The LEAF-Q has been validated in a study with female endurance-trained athletes and showed high sensitivity and specificity (Melin et al., 2015). Although research into LEA has increased over recent years, there are still relatively few studies assessing prevalence with regard to performance level and age within endurance sports (Logue et al., 2019).

Identifying ED in athletes can also be problematic using traditional tools such as the Eating Disorder Examination Questionnaire as many behaviours that may be considered normal in an athlete, may be considered abnormal in the general population (Knapp et al., 2014). Therefore, ED risk in female athletes should be assessed using an appropriate tool for this population. The Female Athlete Screening Tool (FAST) is a validated, 33-item questionnaire developed specifically for female athletes, with a high internal consistency (McNulty, Adams, Anderson, & Affenito, 2001). The FAST has the ability to differentiate between an athlete with an ED, and behaviours that are aimed to enhance performance but are not pathological (Knapp et al., 2014). It is the only questionnaire with the ability to identify the risk of both subclinical DE and clinical ED (Knapp et al., 2014). A combined approach using both LEAF-Q and FAST to identify the risk of LEA, DE and ED has been used successfully in previous research (Folscher, Grant, Fletcher, & van Rensberg, 2015; Sharps, Wilson, Graham, & Curtis, 2021); however, research within female endurance runners is limited (Folscher et al., 2015).

Current research indicates that female athletes are at greater risk for developing ED and DE than the general population, and are 5–10 times more likely to suffer from an eating disorder than men (Sundgot-Borgen & Torstveit, 2010). Reported prevalence of EDs in female athletes ranges from 6 to 59% (Folscher et al., 2015; Sundgot-Borgen & Torstveit, 2004; Bratland-Sanda & Sundgot-Borgen, 2013; Ackerman & Misra, 2018; Meng et al., 2020). A higher prevalence of ED has been reported in sports that emphasise leanness for improved performance, and/or that require body-revealing clothing in comparison to sports where leanness is not a performance requirement (Folscher et al., 2015; Slater et al., 2016; Turton, Goodwin, & Meyer, 2017). Endurance athletes, both competitive and recreational, are considered to be at higher risk compared to the general population, likely because of the increased energy demands (Torstveit & Sundgot-Borgen, 2005). Furthermore, athletes participating at a competitive versus recreational level are considered at higher risk of DE or ED (Sharps et al., 2021; Turton et al., 2017). However, research is limited, and reported prevalence rates are equivocal due to the varied methodologies used and wide range of sporting populations tested (Folscher et al., 2015; Sundgot-Borgen & Torstveit, 2004; Bratland-Sanda & Sundgot-Borgen, 2013; Ackerman & Misra, 2018; Meng et al., 2020).

The primary aim of the current study was to identify the risk of LEA in pre-menopausal, female endurance runners in different age groups and levels of competition using the LEAF-Q. A secondary aim was to determine the prevalence of eating disorders and disordered eating behaviours using the FAST questionnaire and identify any associations with the risk of LEA.

2. Materials and methods

2.1. Participants

Following initial pilot work to ascertain the Flesch-Kincaid readability score (65.0), a cross-sectional descriptive study design (via anonymous, online questionnaire; Qualtrics; Provo, Utah, USA, 2019) was utilised to ascertain the prevalence of ED, DE and risk of LEA in female endurance running athletes. Inclusion criteria were: aged ≥18 years, participating in regular running activities at a recreational or competitive level, not currently pregnant, no injuries nor experiencing any peri-menopausal or menopausal symptoms. These inclusion criteria were specified within the participant information sheet at the start of the questionnaire, and participants were asked not to complete the questionnaire if they did not meet criteria. Participants were asked to self-report their competitive level. As per the methods of Sharps et al. (2021), competitive athletes were defined as any athlete undertaking ≥6 h of training per week with a view to participate in official competitions (e.g. university, club level athletes or higher) and whose full-time job was not that of a full-time athlete (McKinney, Velghe, Fee, Isserow, & Drezner, 2019; Sharps et al., 2021). Recreational athletes were defined as those undertaking ≥4 h of training per week who did not receive any money for partaking in sport and participated for enjoyment (McKinney et al., 2019; Sharps et al., 2021). Participants were grouped into one of the following age categories; 18–24 years, 25–30 years, 31–40 years and 40+. Primary running distance was also self-reported and then categorised based on participant responses (3000 m to 10 km, 10 miles to half-marathon and marathon/ultra). The study received institutional ethical approval and all participants provided informed consent prior to completing the survey. The survey was available to participants between May 2020 and July 2020. All procedures performed in studies involving human participants were in accordance with the ethical standards of the Code of Ethics of the World Medical Association (Declaration of Helsinki, 1964 and Declaration of Tokyo, 1975, as revised in 1983).

2.2. Online questionnaire

Both LEAF-Q and FAST were utilised as per the methods of Sharps et al. (2021) and uploaded manually to an online survey platform (Qualtrics; Provo, Utah, USA, 2019). Once completed, the survey links were distributed via social media channels and email advertisements. The questionnaire required data on participant age, competitive level and running distance. Following this, participants were asked to complete the LEAF-Q and FAST questionnaires, respectively. Forced responses and skip logic were utilised in both the LEAF-Q and FAST to ensure participants were unable to skip relevant questions, and that they were directed to appropriate follow-up questions within the surveys.

2.3. Low energy availability in females questionnaire (LEAF-Q)

The LEAF-Q is a validated screening tool that consists of 25 questions on injury history, gastrointestinal function, menstrual function and oral contraceptive use (Melin et al., 2014a). Injury and gastrointestinal discomfort were assessed by ordinal scales and an open category to specify the types of injury/illness, etc. Menstrual function and oral contraceptive use were assessed by dichotomous and ordinal scales. Participants were considered at risk of LEA if a score of ≥8 was attained (Melin et al., 2014b).

2.4. Female athlete screening tool (FAST)

FAST is a validated screening tool to identify eating pathology in female athletes, consisting of 33 questions (McNulty et al., 2001). Participants were required to select a response from four possible answers (4 points (pts) = Frequently, 3 pts = Sometimes, 2pts = Rarely, 1 point = Never) with a reverse scoring system used for questions 15, 28 and 32. Responses were totalled to give an overall score indicating the risk of DE/ED. A score of 74–94 indicates the risk of subclinical DE whilst a score of >94 indicates the risk of clinical ED (McNulty et al., 2001).

2.5. Statistical analysis:

All data were analysed via SPSS (IBM Corp. Released 2017. IBM SPSS Statistics for Windows, Version 25.0. Armonk, NY: IBM Corp). Normality was assessed via Shapiro–Wilk test. A one-way ANOVA or Kruskal–Wallis was used to identify differences in FAST and LEAF-Q means and age category, competitive level and running distance, respectively. Post-hoc testing was conducted where appropriate. Chi-squared or Fishers Exact tests were used to determine if the percentage of those categorised above/below FAST and LEAF-Q cut-offs differed based on age, competitive level and running distance. Bonferroni corrections were applied where appropriate. Following this, a stepwise multiple regression analysis was carried out to determine the contribution of age category, competitive level and running distance undertaken to final questionnaire scores (both FAST and LEAF-Q). A variance inflation value (VIF) of less than 5 was considered acceptable (Ruengvirayudh & Brooks, 2016). Finally, a Spearman's rank correlation was conducted to determine the relationship between FAST and LEAF-Q. An alpha level of $p \leq .05$ denoted significance.

3. Results

3.1. Participant characteristics

A total of $n = 609$ female runners completed the self-administered, online questionnaire, of which 85 were excluded for incomplete questionnaires, with no responses excluded for not meeting the inclusion criteria. Therefore a total of $n = 524$ responses were eligible and was included in the final analysis (Table 1). Participants were grouped into recreational ($n = 403$, 77%) and competitive runners ($n = 121$, 23%). Post-hoc power analyses were undertaken, with effect size (*ES*) calculated from LEAF-Q means of each group (recreational, competitive; *ES*: 0.32) with $\alpha = 0.05$ (two-tailed), which determined beta at 0.87.

3.2. LEAF-Q questionnaire scores

Results from LEAF-Q can be seen in Table 2. A total of $n =$ 248 athletes (47.3%) were considered at the risk of LEA. LEAF-Q scores differed based upon age (Age: $H_{(3)} =$ 23.998, $p \leq .05$) and competitive level (Comp: $H_{(1)} =$ 7.682, $p \leq .05$). Post-hoc pairwise comparisons indicated those who were within the 25–30 years, 31–40 years and 40+ years age categories had lower LEAF-Q scores vs. 18–24 years (all $p \leq .05$). LEAF-Q categories did not differ based on competitive level or distance (Fishers, $p \geq .05$), but did differ based upon age (Fishers, $p \leq .05$). Post-hoc testing revealed a higher percentage in the 18–24 years category had greater LEA risk (73%) vs. LEA no risk (27%). Stepwise multiple regression demonstrated age and competitive level modestly predicted LEAF-Q scores ($R^2_{adj} = 0.047$, $F_{(2,523)} = 13.993$, $p \leq .05$, VIF = 1.0; Table 3).

3.3. FAST questionnaire scores

Results from FAST can be seen in Table 2. A total of $n =$ 209 athletes (40%) were at risk from DE and $n = 49$ athletes (9.4%) were at risk of ED. FAST scores differed based on age (Age: $F_{(3,523)} = 4.753$, $p \leq .05$). Tukey's post-hoc tests showed significantly higher FAST scores in 18–24 years compared to all other age categories ($p \leq .05$). There was no difference of FAST categories between competitive level or distance specialism (Fishers, $p \geq .05$). Post-hoc testing highlighted greater number of recreational athletes was at risk of subclinical DE FAST category (40.7%), when compared to the risk of clinical ED (8.7%) and no risk of ED (50.6%). Competitive athletes were at risk of subclinical DE FAST category (37.2%), when compared to the risk of clinical DE (11.6%) and no risk of ED (51.2%). Stepwise multiple regression demonstrated age modestly predicted FAST scores ($R^2_{adj} = 0.022$, $F_{(1,523)} =$ 12.711, $p \leq .05$, VIF = 1.0; Table 3).

3.4. LEAF-Q and FAST questionnaire scores

A positive, weak correlation between FAST and LEAF-Q scores was observed ($r_s = 0.238$, $p \leq .05$) indicating a relationship between DE/ED and LEA in female endurance runners.

4. Discussion

The primary aim of this study was to determine the prevalence of ED, DE and LEA within competitive and recreational female endurance athletes in the UK. A combined approach of using LEAF-Q and FAST was implemented to ascertain eating pathology and areas related to LEA. The primary findings were: (1) LEAF-Q indicates 47.3% of female endurance runners were considered at risk of LEA, (2) FAST indicates 9% and 40% of female endurance runners were at risk of ED and DE, respectively and (3) a small positive correlation between FAST and LEAF-Q scores indicates a relationship between DE/ED and LEA.

To the authors' knowledge, limited studies have implemented both LEAF-Q and FAST concurrently to ascertain the prevalence of ED/DE and LEA within female athletes. Folscher et al. (2015) found 5%, 27% and 44% of participants at risk of ED, DE and LEA, respectively, whereas the present study demonstrates a higher prevalence of ED and LEA in UK-based, female endurance runners. Folscher et al. (2015) reported that participants included both recreational and professional endurance runners; however, unlike the present study, no sub-group analyses were conducted to identify differences in FAST and LEAF-Q between competitive levels. When analysing female athletes across a range of different sports, competitive levels and age classifications, Sharps et al. (2021) found that 16%, 44% and 53% of female athletes were at risk of ED, DE and LEA, respectively. Using sub-group analysis, their research indicated that age was a predictor of LEAF-Q scores whilst competitive level influenced, and was a predictor of, FAST scores. These findings are comparable to those presented in the current study and suggest that both age and competitive level may be an influencing factors in the prevalence of ED, DE and LEA within female athletes (Sharps et al., 2021) and, more specifically, female endurance runners. Our findings are also consistent with research in female athletes participating in various sports where LEA was assessed via the LEAF-Q (Logue et al., 2019; Meng et al., 2020; Slater, Brown, McLay-Cooke, & Black, 2017). Using LEAF-Q, Heikura et al. (2018) reported amenorrhoeic female distance athletes had higher LEAF-Q scores compared to those who were eumenorrheic (LEAF-Q: 12.8 ± 4.8 vs. 8.3 ± 3.7, respectively) (Heikura et al., 2018). Similarly, Condo, Lohman, Kelly, and Carr (2019) reported a lower LEA prevalence (30%) in professional female Australian rules football players than in the present study.

Table 1. Descriptive statistics from all eligible questionnaire responses.

	Age (years)				Competitive level		Distance		
	18–24	25–30	31–40	40+	Recreational	Competitive	3000 m to 10 km	10 miles to half-marathon	Marathon/ultra
Responses (*n*=)	74	167	168	115	403	121	269	205	50
Category (%)	14	32	32	22	77	23	51	39	10

Although both studies used LEAF-Q, the cohorts in these studies were smaller than those reported within the present study ($n = 35$, Heikura et al., 2018, $n = 27$, Condo et al., 2019 vs. $n = 524$), therefore caution must be exercised when attempting to draw comparisons between data.

Previous self-report studies have described higher rates of both LEA and DE in control groups compared to athletic cohorts (Reinking & Alexander, 2005; Rosendahl, Bormann, Aschenbrenner, Aschenbrenner, & Strauss, 2009). These findings are in contrast to those reported by Martinsen and Sundgot-Borgen (2013) who utilised both self-report measures and clinical interviews to assess prevalence in female and male adolescent elite athletes versus non-athletic controls. When using self-reporting measures, non-athletes had a higher prevalence of ED (Athlete: 25%, control: 51%, $p \leq .001$) yet, after clinical interview adolescent athletes were seen to have higher ED prevalence (Athlete: 7%, control: 2%, $p \leq .001$). This suggests that self-report measures alone are potentially inaccurate as adolescent athletes may over-report their symptoms. Within the present study, participants aged 18–24 years demonstrated the highest rates of ED and LEA (19% and 73%, respectively), findings which are further supported by our multiple regression analyses, indicating that age was a predictor of FAST score. These findings support the potential for additional screening to be implemented within younger age athletes to identify risk factors associated with ED, DE and LEA.

Our findings suggest competitive endurance runners have higher rates of LEA risk (53.7%) and ED (11.6%) compared to recreational endurance runners; however, recreational endurance runners had greater DE risk (40.7%). These findings are further supported by our multiple regression analyses, which indicate that competitive level was a predictor of LEAF-Q score. Additionally, Logue et al. (2019) observed higher risks of LEA among females who participated competitively in sport compared with those who were recreationally active (77% vs. 23%, $p = .01$), with LEA risk 1.7–1.8 times more likely among participants who reported competing in sport at international (45%) or provincial/inter-county level (47%), compared to those who were recreationally active (Logue et al., 2019). Similarly, Slater et al. (2017) reported 45% of recreational female athletes to be at risk of LEA according to LEAF-Q scores. Both of these studies report similar rates of LEA risk as those presented in the current investigation (competitive: 53.7%, recreational: 45.4%). Logue et al. (2019) proposed that higher level athletes are more prone to LEA due to generally higher training intensity and duration than their recreational counterparts, which may partly explain the increased LEA risk in competitive athletes in the present study. Endurance athletes are often suggested to be at greatest risk of LEA (Folscher et al., 2015; Pollock et al., 2010) which could be associated with excessive energy expenditure, with an increased risk of LEA for each additional hour of exercise per week (Logue et al., 2019). These findings suggest higher rates of LEA (and possible consequent DE) are likely due to increased energy demands in competitive athletes not being met. Whilst recreational female endurance runners may also be at risk of DE and LEA, the reasoning behind such risks is not fully clear. It may be that recreational endurance runners are less likely to have nutritional support compared to more competitive level endurance runners, and may be at greater risk of unintentional DE and LEA (Slater et al., 2017).

Early intervention is essential to attenuate negative health and performance consequences of ED, DE and LEA (de Bruin, 2017). Knowledge of ED, DE and LEA and their health and performance consequences has been shown to be low among coaches and athletes (Logue et al., 2020). During long-term LEA, an individual's weight may remain stable due to energy-saving physiological and endocrine adaptations; therefore, detection of ED or DE may be difficult without screening (Melin, Heikura, Tenforde, & Mountjoy, 2019). Screening and educational interventions are considered effective strategies to improve knowledge and awareness of ED, DE and LEA, optimising nutrition to support energy demands (Folscher et al., 2015; Keay, Francis, & Hind, 2018; Melin et al., 2019). Evidence shows that maintaining within-day energy balance is important with regards to preventing the development of LEA (Fahrenholtz et al., 2018). Spending parts of the day in energy deficiency has been associated with higher cortisol levels, menstrual dysfunction, lower oestradiol and reduced RMR ratio in athletes (Fahrenholtz et al., 2018; Logue et al., 2020). This highlights a need for education around nutrient timing to avoid negative within-day energy balance, which may be an important addition

Table 2. Results of FAST and LEAF-Q with response scores *n*= and percentages (%) of participants at risk of ED, DE and LEA and chi-square cross tabulation analysing age, competitive level and distance against FAST and LEAF-Q scores

		FAST			LEAF-Q	
Category	Questionnaire scoring	<74	74–94	>94	<8	>8
	Total scores *n*= (%)	266 (51%)	209 (40%)	49 (9%)	276 (53%)	248 (47%)
Age (years)	18–24	29 (39%)	31 (42%)	14 (19%)	20 (27%)	54 (73%)
	25–30	83 (50%)	73 (44%)	11 (6%)	83 (49%)	84 (51%)
	31–40	92 (55%)	60 (36%)	16 (9%)	103 (61%)	65 (39%)
	40+	62 (54%)	45 (39%)	8 (7%)	70 (61%)	45 (39%)
Competitive level	Recreational	204 (51%)	164 (41%)	35 (8%)	220 (55%)	183 (45%)
	Competitive	62 (51%)	45 (37%)	14 (12%)	56 (46%)	65 (54%)
Distance	3000 m to 10 km	146 (54%)	106 (39%)	17 (7%)	151 (56%)	118 (44%)
	10 miles to Half-marathon	92 (45%)	83 (40%)	30 (15%)	99 (48%)	106 (52%)
	Marathon/ultra	28 (56%)	20 (40%)	2 (4%)	26 (52%)	24 (48%)

to any educational interventions aimed at reducing the risk of LEA (Logue et al., 2020). It could be hypothesised that recreational runners are less likely to attend a formal running club where this kind of information may be available; therefore, it may be pertinent to suggest that educational materials and interventions are also targeted at gyms, fitness centres and healthcare settings (Slater et al., 2016).

Our findings indicate that competitive level is a modest predictor of FAST (accounting for a proportion of 3%), whilst age and competitive level are modest predictors of LEAF-Q (accounting for a proportion of 5%). These observations add to work conducted in female soccer players (Abbott et al., 2021) which, despite adopting differing validated questionnaires (clinical perfectionism questionnaire (CPQ-12) and eating attitudes test (EAT-26)), observed athletic status and perfectionism were significant predictors of DE, accounting for 21% of variation ($p = .001$). Similarly, work by Sharps et al. (2021) found that competitive level was a modest predictor of FAST scores (accounting for a proportion of ~3%) and that age was a modest predictor of LEAF-Q (accounting for a proportion of ~14%) in a range of female athletes. These findings, along with the findings of the present study indicate that competitive level or athlete status may be a risk factor for ED/DE in female athletes. Our multiple regression analysis indicates that despite competitive level being a predictor of FAST scores, accounting for a proportion of ~3%, additional variables may be influencing factors and may be future directions for this research. Information gathered from athlete screening could be utilised to monitor progression of ED/DE risk and implement preventative strategies such as nutritional education or interventions before ED, DE or LEA occurs (Joy, Kussman, & Nattiv, 2016).

Table 3. Results from regression analysis of independent predictors on dependent variables, FAST and LEAF-Q.

Predictor – FAST	*B*	*SE* (*B*)	*β*	R^2
Age (years)	−2.210	0.620	−0.154*	0.024
Predictor – LEAF-Q				
Age (years)	−0.770	0.183	−0.179*	0.030
Competitive level	1.431	0.426	0.143*	0.051

*Indicates statistical differences at $p \leq .05$ level.

Despite offering further insight in to the risk of ED, DE and LEA within female endurance runners, the present study is not without limitations. The study only recruited participants from within the UK, and because of this, findings may not be representative of female endurance runners from differing countries and cultures. It is also important to highlight that this study assessed the risk of ED, DE and LEA via an anonymous, online, self-report questionnaire. Although both FAST and LEAF-Q questionnaires have been widely used and provide clinical sensitivity, they can only detect individuals who may be at risk of developing ED, DE or LEA and would require a clinical follow-up before diagnosis (Sharps et al., 2021). Subsequently, future investigations into the prevalence of ED, DE or LEA may wish to consider implementing clinical interviews, biochemical and/or exercise testing within female endurance runners to further support findings from survey data. Consequently, findings from the present study are limited to prevalence estimations and general risk of ED, DE and LEA within female endurance runners from the UK. Finally, the aim of this study was to observe the prevalence of DE, ED and LEA within female endurance runners within the UK, and subsequently, no control group was implemented for comparison against this cohort. Future research may wish to utilise such methodologies, enabling comparisons between female endurance runners of varying demographics and corresponding sedentary female cohorts.

5. Conclusion

Overall, 9% of female athletes were at risk of ED, 40% were likely to have DE and 47% had LEA. Nevertheless, despite risk of DE, ED and LEA evident in all subgroups, our findings suggest female endurance runners within the 18–24 years category were at the greatest risk. This highlights the need for regular screening in order to aid early interventions to prevent potential decrements in performance and health as endurance runners mature. Additionally, nutrition strategies, and where feasible, education programmes, may need to be considered to inform female endurance runners, interdisciplinary practitioners and coaches of potential negative effects of ED, DE and LEA on performance and health. This statement may be particularly pertinent in situations where female endurance runners may be aiming to manipulate energy intake to elicit a specific training adaptation (e.g. modify body composition, increase in training load). Future research could further investigate potential ED/DE issues using a combined approach of the methods adopted within the present study, clinical interviews and detailed athlete screening to clarify these findings.

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